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Original Article

Productivity Improvement In Companies of A Wooden Furniture Cluster In Peru

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Abstract *- During these times, productivity in furniture stores, especially in SMEs, has taken on vital importance, thus compromising the growth of these companies in the market. Productivity is exposed since unproductive times are generated by activities that do not add value to the final product. The present study seeks to increase productivity by addressing the reasons and root causes identified in the study, the high downtime due to disorder in the area (42.1%), delays due to a poor work method (36.7%), and shortage of materials and supplies (21.2%). The proposed model is based on the tools that address the identified reasons: System Layout Planning (SLP) in order to correctly redistribute the work floor, Standardization Work (SW) improves the processes and activities carried out by operators and 5S's to improve the work environment that allows increased productivity in the company under study, achieving a competitive index in the international market. Among the main results of the investigation, the reduction of travel times, an increase in the 5S audit rating, and an increase in value-added time were obtained. In conclusion, the implementation of the proposed model achieves the objective of increasing productivity by reducing production time by 42% so that the units to be produced increase from 78 to 98 upholstered furniture.*

Keywords — *Furniture Industry, Systematic Layout Planning, Lean Manufacturing, Productivity, SMEs.*

I. INTRODUCTION

Furniture production at a global level is in a constant innovative process. More and more countries are increasing their production despite not having a great scope of raw material, such as forest forests. However, their processes are what have allowed them to continue growing within the world market, so that countries such as China and the United States represent 53% of the world distribution of furniture production, which makes them the main powers in the sector [1]. The furniture manufacturing industry in Peru is a sector that has a 78% share in the wood manufacturing market, being one of the most important in the second transformation production chain of the wood sector [2]. At the level of economic activities in the wood sector, furniture manufacturing obtained a sales value, during 2017, of USD 604'000,431, being the percentage with the highest participation in total sales among the production chains of the wood sector [3]. Within the production chain of the second transformation, the participation of Micro and Small companies (MYPE) represents a great contribution in the sales registered in the sector (57%), surpassing large companies by far (39.8%) [4]. Furniture manufacturing had a correct individual performance during 2019, obtaining a 20.1% percentage variation of the physical volume index of manufacturing production (IVF), contributing to the improvement of this index in its subsector [5]. According to data from the Ministry of Production (PRODUCE), during 2019, furniture production presented variable IVF values, having a maximum value of 150.6 and a minimum of 102.6, which identifies irregularities within the monthly evolution of production [6]. This is a clear example that within organizations, there is no control in production, the factors that can cause these variations are different, which is why the need arises to analyze each one of them and identify the tools that can solve them. or design a proposal that mitigates them.

Maintaining low control in the sector will harm the production of companies, as MSEs are mainly the companies with the largest participation in this sector. They cannot continue with their growth since their production level is limited against large companies with which they compete in the market [7]. High unproductive times, lack of process controls, inadequate workplaces, and the lack of clear procedures, among others, brings with it low productivity, which does not allow it to open up to new commercial horizons [8]. When visiting the Villa El Salvador Industrial Park, it is possible to identify the great mass of producers and the states in which their work plants are located. A problem that, although it has been identified, does not receive due importance [9]. The problem has been replicated in other investigations of the same sector; in an investigation carried out to the entire sector of the Villa el Salvador Industrial Park, the average productivity of the furniture-producing companies was found, for which a value of 1.60 was obtained. x10-3. This value was compared with the productivity of furniture producing companies in Colombia, and a comparison was made with this country since market conditions, economic reality, among other factors, are very similar, which was 2.05x10-3, that comparison evidence that there is a difference of approximately 20% between both values, so it is necessary to provide solutions to the problems of the furniture industry in Peru to improve productivity [10].

Given this problem and based on the literature review, a model has been proposed through the implementation of Systematic Layout Planning (SLP) and Lean tools such as 5S's and Work Standardization. The first phase consists of analyzing the redistribution of workspaces within the company's production plant. Given that there is evidence of problems in the routes traveled by the operators, it is proposed to reduce distances to make better use of time in the main tasks [11]. In addition, by making the most of the spaces, the productive flow would change, allowing new working methods to be generated given the newly defined areas and establishing a new order in each one of them. For this reason, in the second phase, the 5S's are developed with the purpose of reordering each of the spaces for the benefit of the development of the activity, ensuring that these are respected once established, reducing search times for materials, for example [12]. In the third and final phase, the application of work standardization, to evaluate the activities carried out by each of the workers and propose an alternative that improves the process [13], achieving the objectives, but without modifying the final result.

This article is made up of six main parts, each of which shows the development of the research. Within the analysis of the problem, there is the diagnosis made to the company H43, through which the main reasons to be solved to achieve increased productivity were found. Below is the Background where all the information that has been reviewed to formulate the diagnostic tools and the innovative proposal is presented. The latter is developed as the contribution of the authors after conducting an extensive review of different success stories and that by integrating them, they achieve the fulfillment of the proposed objectives. Finally, the validation part collects the information that is going to be entered in Arena Simulation of the current state, and after the implementation of the Lean tools, the new, improved model was developed in order to determine if it is viable and meets the objective.

II. BACKGROUND

A. About the technique

The Lean Manufacturing methodology helps to improve and optimize the production process, reducing or eliminating activities that do not generate any value for the final product. These activities are known as wasteful activities since they do not benefit the customer, and neither do they improve the production process, but rather they harm and make it less efficient [14]. Its main objective is to reduce the losses that are generated in each process, referring to the losses in production and using resources that are clearly necessary. In conclusion, applying Lean Manufacturing would have a direct impact on quality improvement, cycle time reduction, and cost reduction [15]. Thanks to the implementation of the Lean Manufacturing methodology, companies will be able to satisfy customer needs in terms of product quality, cost, and delivery time, optimizing profit [16]. The main disadvantage of Lean Manufacturing is the high cost of this methodology, which makes its implementation difficult for medium and small companies [17]. In addition to this, when you want to choose to carry out a methodology, it is because the company is in a situation in which the market and competitiveness are at risk. Therefore, the loss of confidence may increase, and this would be generating damage. The application of the Sipoc Tortuga allows to identify and define each of the parts, to know where a process begins and ends clearly; this means to know what the limits are. It helps to establish the interactions of the processes, who is in charge of each of them, and what is needed to carry them out [18]. The standardization of work consists of identifying the best practices of each operator, which has been proven to obtain optimal results to establish as a new work method, which everyone must exercise in their work. In other words, all operators are required to work in the same way for a specific production process [13]. This tool also helps to determine the standard time in each process, and it is for this reason that it is a complementary tool with Method Engineering, particularly in the definition and implementation stages [19]. It is worth mentioning that this tool does not pay for the operations carried out in the process under study. Value Stream Mapping is a tool belonging to the Lean Manufacturing methodology, and its application helps to visualize and analyze in order to improve the flow of products within each process, from when the material enters production until the final product reaches the customer. The VSM implementation process is based on a scheme of the current state of the production process, which identifies all the problems that affect excessive times, bottlenecks; likewise, to be able to establish the improvements to give it a solution, which is applied through the focus on optimizing the flow of material and information, as mentioned in the concepts of Lean [20]. After that, a future scheme is made, which would be ideal for the company; it would no longer reflect the problems, it is for this reason that productivity will improve and resources will be better used [21]. The 5S methodology combines activities with each other to achieve optimal working conditions. With timely maintenance of the workplace and the use of visual signals, the production flow improves productivity and reduces waste [22]. The objective of 5S implementation is to be able to carry out all activities in an organized manner, with high standards of cleanliness, and in an orderly manner to correct production processes and achieve the highest possible efficiency and profitability [23].

B. About the problem

Sellito[24] demonstrated that unbalanced flow in the manufacturing process results in excessive WIP that increases operating cost and lead times. The method is based on techniques related to workload control (WLC) for good management in production. One of the main characteristics of this method is to integrate the production planning and control techniques more suitable for the workshop that works in custom production (MTO) [24].

Sujova et al. [25] conclude that there is a significant dependence between the identified input parameters and the effectiveness of the manufacturing process represented by the level of cost per sub-process, the quality of the part to be machined, and the total duration of the sub-process.

Dušak et al. [26] propose the use of the AHP method, by means of which it is hoped to discover those factors of advantage and disadvantage of wood processing and furniture manufacturing in the countries of Southeastern Europe. It is concluded that managers of SMEs dedicated to the manufacture of wooden furniture should focus their attention on three fundamental factors in production:

- Market and trade activities (24.91%)
- Product quality (19.59%)
- Information technology versus modern production technology (14.78%)

C. About innovative technique

Burawat[27] contributes to current research by examining productivity enhancement by implementing 5S and removing Muda to decrease non-valued work. As a result, it was obtained that the production of corrugated cardboard increased from 2,000 tons to 2,300 tons per month, which represents 15% of the improvement. The defects that were obtained in the production due to poorly managed processes were reduced from 160 pieces to 140 pieces per month, which means a 12.5% improvement.

Kishimoto et al. [28] had a problem regarding the fulfillment of deliveries on time in the company under study. Being use of tools such as 5S, VSM, Kanban, Kaizen, and Heijunka, with the consideration of being able to combine them to obtain better results. In conclusion, the implementation increased the orders delivered on time by approximately 46%, providing a great improvement to the problem.

Mor et al. [13] state that AVNs (Non-Value Added Activities) were eliminated using SW (Standardized Work Diagram) procedures and that he opted for SW because it is a set of actions that helps to analyze, improve and control the process and leads to continuous improvement. As a result, 31.6 s of time were saved per product period, which increased production to 58 “A” pieces versus the existing production of 45-50 “A” pieces in a 7-hour work shift.

Linset al. [29] propose a methodology for the analysis of the process flow of the physical space (Systematic Layout Planning) of the design of the industrial installation that allowed to identify the opportunities for cleaner production. After the implementation, the reduction of waste related to the movement of people and materials was obtained, and the generation of waste at the source was also reduced.

Emelianova et al. [30] propose a methodology based on standardized work to organize and plan information for the stages of the production of a product. The results of this research determine a certain methodology for companies to take a Standardized Action Plan, methods to adapt and implement the standardized action plan in their production processes and techniques to evaluate the effectiveness of its implementation, generate continuous improvements in the processes standardized and correct quality management.

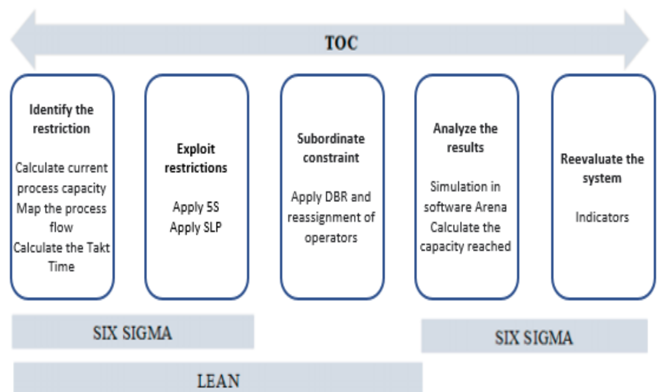
D. About innovative technique

Industry experts, academics, analysts from commercial organizations and contractors with knowledge in the promotion of automation were surveyed and study the concepts of Industry 4.0 on a recurring basis. The author mentions a low capacity within the furniture production sector to adopt technology; approximately 96% of respondents do not see it necessary to make a high initial investment involved in technology, their lack of information network infrastructure and data management within its manufacturing facilities is the main factor [31].

III. INNOVATIVE PROPOSAL

A. Basis

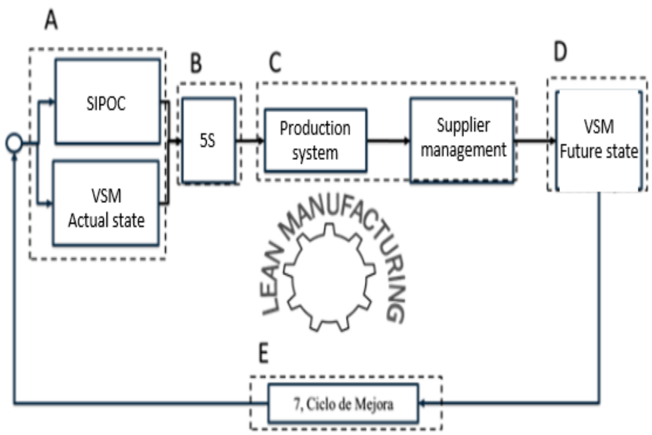
Within the literature review to identify those tools that will serve in the design of the innovation proposal, the authors Bazan and Chavez proposed a model based on the TOC, SLP, and 5S's tools to improve productivity [10]. That was developed within the furniture manufacturing sector of Villa El Salvador, so it represents a great source of inspiration for the innovation proposal of this research.



Source: Chavez et al. [10]

Figure 1. Design of the motivation model

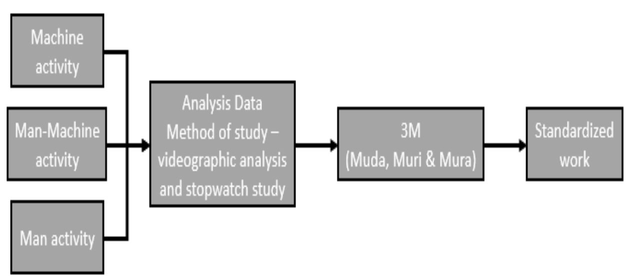
In Figure 2, the authors Barzola and Calderon developed a model with tools from the Lean Manufacturing methodology, with the aim of achieving increased productivity within the textile sector. The development of each tool is presented by grouping it into components, and each component can group more than one tool that allows it to complement the solution of the identified causes [32]. The sector where this research is carried out behaves in a very similar way to that of the authors, family businesses, with little technological investment and controlled by low prices, so the authors' model will serve as motivation for the development of a new one.



Source: Barzola and Calderon [32]

Figure 2. Design of the motivation model

Continuing with the review of models, it was found that, in the country of India, the authors Mor et al. developed their research within a wooden furniture manufacturing company, focusing on the elimination of changes and standardizing a new process that allows avoiding those activities that do not generate value. After evaluating the processes, the authors propose a new work sequence, defined under stations that maintain a continuous flow together with a moderate stock. For this reason, each process within the investigation will have vital importance in the application of each tool, with the objective that an optimal flow can be generated for the company under study [13].



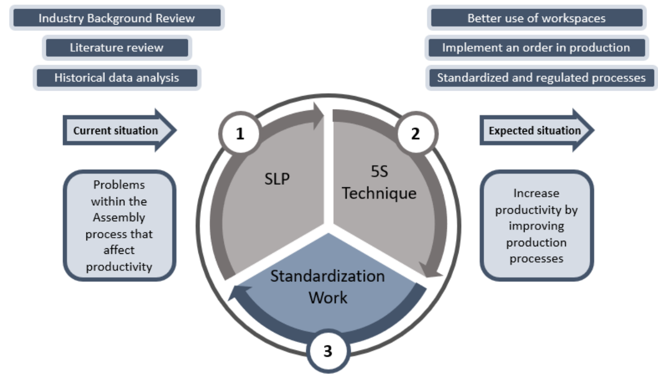
Source: Mor et al. [13]

Figure 3. Design of the motivation model

B. Proposed model

Within the innovative proposal that is developed in this research, SLP (Systematic Layout Planning), 5S, and Standardization Work tools are linked to attack the identified reasons.

Next, the flow diagram is presented (Figure 5) for the development of the three phases of the proposed model that will allow increasing productivity within the company under study.



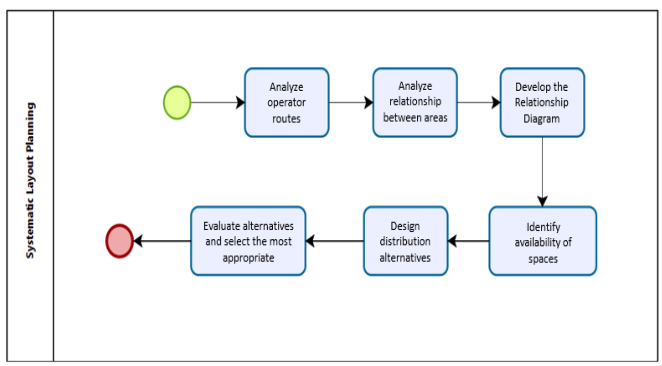
Source: Self-made.

Figure 4. Innovative Proposal Model

C. Model detail

Component 1: Systematic Layout Planning (SLP)

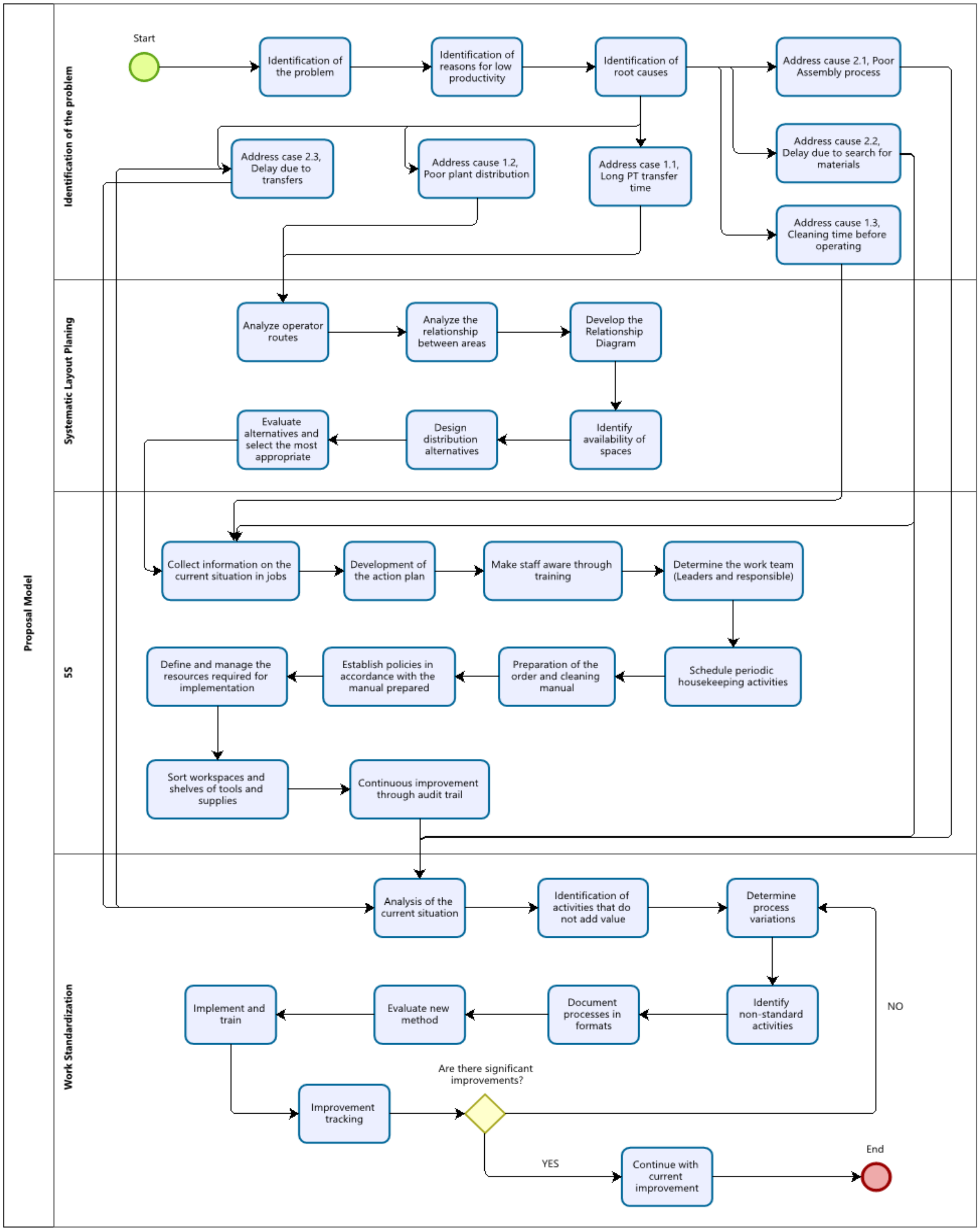
Through the implementation of the Systematic Layout Planning (SLP) tool, the high transfer times of the finished product that represents 30.4% and the deficient distribution of the plant that represents 26.5% will be addressed. In addition to correctly distributing the spaces on the work floor and improving the productive flow of the company under study. The development of the tool is shown in Figure 6:



Source: Self-made.

Figure 6. SLP implementation flow chart

According to the development of the SLP tool, it is possible to identify different factors to take into account for the development of new proposals. The relationship between areas, together with the adequate identification of spaces, will allow the new distributions to obtain better results than the current state [11].

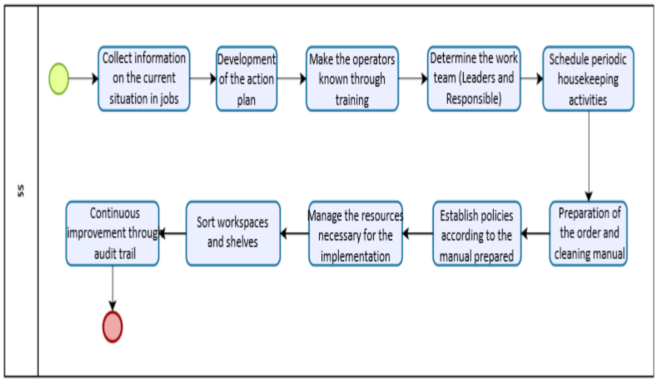


Source: Self made.

Figure 5. Flowchart of the implementation of the proposal

Component 2: 5S's

The implementation of the 5S will allow reducing the activities that do not generate added value to the production processes, such as the search for materials and tools; Through good management, a safe, orderly and clean work environment will be achieved. Next, the flow diagram of the implementation of this methodology will be presented.



Source: Self-made

Figure 7. 5S implementation flow chart

For the development of the tool, it is important to identify the necessary and unnecessary processes. With this, develop an action plan to address the causes that give rise to reason 1, poor work method. Likewise, it is necessary to train the personnel to make them aware of and to be able to correctly manage the resources for the implementation. It is worth mentioning that monitoring is done through 5S audits to have control and record continuous improvements.

Component 3: Standardization Work

Through the implementation of the Lean tool, work standardization (SW), seeks to improve the processes that are carried out in the production workshop, and this is done to address three main causes that affect the critical Assembly process; deficient process, delay in searching for materials, and delay in transfers, these are considered as activities that do not add value. The SW application is carried out according to Figure 8.

Work standardization is presented as the most suitable tool to eliminate those activities that do not generate value within the production flow. Likewise, they generate a new process based on the elimination of the MUDAS, previously identified [13]. As a result, a new process is implemented with the suggested measures to take advantage of the time in those activities that add value to the production of the company under study.

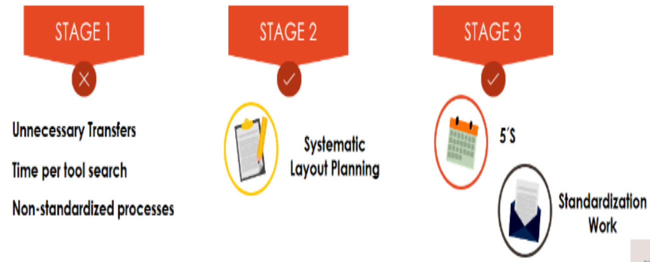
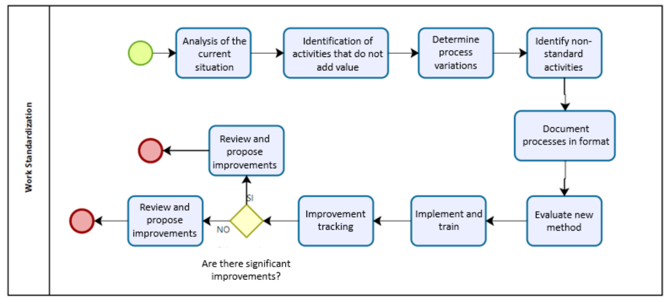


Figure 8. Flowchart of Standardization Work implementation



Source: Self-made.

Figure 9. Validation scenarios

D. Indicators

Productivity

The indicator allows maintaining control regarding the use of resources that are used in the production of upholstered chairs.

Travel time

Measures the travel time of operators when carrying out upholstered furniture production activities.

5S Audit

Reviews compliance with the determined standards quickly identifies anomalies, and proposes collective corrective actions.

Value-added

Its purpose is to determine that process that does not meet the minimum percentage to be considered effective.

Table 1. Project Indicators

Indicators	Formula	Light	
Productivity	$\frac{Production\ Obtained}{total\ input}$		$< 1.60 \times 10^{-3}$
			$1.60 \times 10^{-3} < X < 2.05 \times 10^{-3}$
			$> 2.05 \times 10^{-3}$
Travel time	*Making times*		$> 30\ min$
			$20\ min < X < 30\ min$
			$< 20\ min$
5S audit	*Audit file*		$< 50\%$
			$50\% < X < 60\%$
			$> 60\%$
Value Added Index	$\frac{value\ added\ time}{total\ input}$		$< 75\%$
			$75\% < X < 85\%$
			$> 85\%$

Source: Self-made

IV. VALIDATION

A. *Testing Scenario*

In accordance with the development of the project, the simulation of the current situation and the improvement proposal was carried out in the Arena 14.0 software. For the software, it was necessary to enter the current data under which the production of upholstered furniture is carried out, such as cycle time, work hours, number of operators, and the time distributions of each process based on the time taken. Previously. A confidence level of 90% was taken into account with a margin of error of 10%, with which it was obtained through the Output Analyzer that 2368 repetitions must be made so that the results closely resemble reality.

B. *Initial diagnostic*

According to the research carried out previously, it was possible to identify three main reasons why the productivity of the company under study does not reach a competitive index [33], these are:

- High downtime due to disorder in the area
- Time due to poor work method
- Shortageofmaterials and supplies

By knowing how each reason affects the assembly processes, these values served to take them into account within the simulation of the current situation:

Table 2. Results of the simulation of the current scenariol

	Scenario 1 (current)
Accumulated Finished Products (In 2368 replicas)	7480
Accumulated Demand (In 2368 aftershocks)	15167
Efficiency with Accumulated Data	49.32%
Monthly Average of Finished Products (1 month = 25 days)	78
Average Demand (1 month = 25 days)	160
Monthly Average Efficiency	48.75%

Source: Self made.

Startup

In order to identify the system to be carried out in Arena Software, a graphic representation of the upholstered furniture production process was made. In this, it is possible to identify those tasks that are carried out in parallel, in addition to placing each distribution of time that must be recorded for the simulation, then the result is shown in Figure 11.

Simulator Results Analysis

By simulating the model (current state), it was obtained as a result that the total cycle time is 246 minutes, which is equivalent to 4.1 hours, and that 78 units of upholstered furniture are produced in a month as a period of time. It is worth mentioning that the simulation yields data very similar to reality.

Table 3. Current cycle time in minutes

	Reality	Simulation
Cycle Time (hrs)	4.09	4.1
Unit Produced (unit)	77	78

Source: Self made.

After validating the current state, verifying that the results resemble reality, the improvements were made.

For the first improvement (scenario 2), the Systematic Layout Planning (SLP) tool is implemented, which will allow to manage the layout of the production plant and thus eliminate unnecessary transfers, the new structured workstation that will be executed was also created. By two operators. The second improvement (scenario 3) is implemented using the 5S's and Standardization Work (SW) tools; This will help with order and cleanliness, eliminating time spent searching for materials and tools, apart from modifying the activities of the structured process, eliminating unnecessary activities and standardizing the process, generating a decrease in cycle time.

As can be seen in the following figure, after the implementation of the improvement proposal, the simulator shows as a result that the new total cycle time is 117 minutes, which is equivalent to 1.95 hours, demonstrating a noticeable improvement.

Table 4. Cycle time implementing the improvement

	Scenario 1 (current)	Scenario 3 (upgrade 2)
Cycle Time (hrs)	4.1	1.95

Source: Self-made.

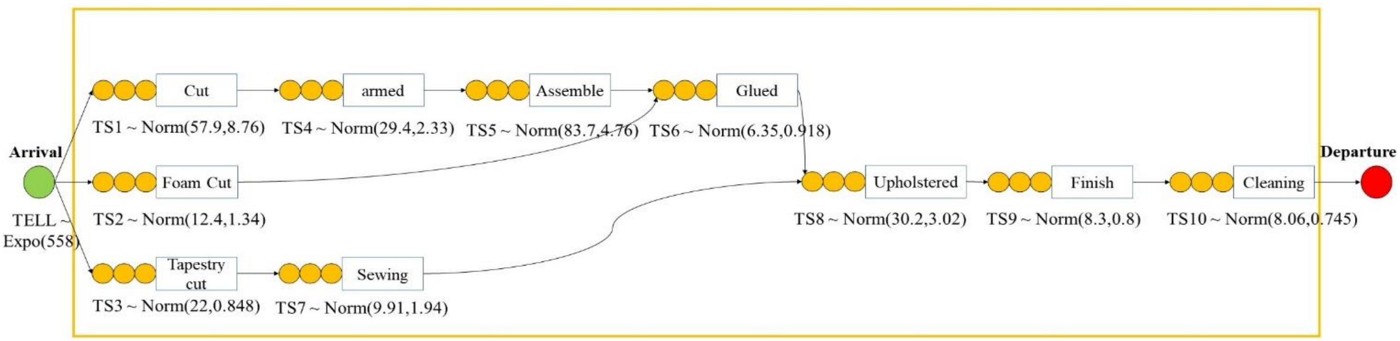
C. *Final results*

In table 5, it can be seen that after the implementation of the two improvements, the number of finished products has increased from 78 units to 98 units in a period of time of 25 days, which is the working time in a month in H43. This increase in monthly production has generated an improvement in efficiency with respect to demand, and it went from 48.75% to 61.25%. Therefore, the improvement proposal is viable since positive results are obtained in the Arena simulation.

Table 5. Results of the improvement scenarios

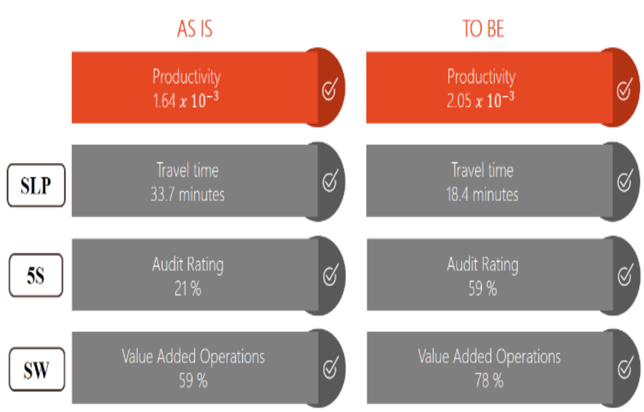
	Scenario 2 (upgrade 1)	Scenario 3 (upgrade 2)
Accumulated Finished Products (In 2368 replicas)	9076	9328
Accumulated Demand (In 2368 aftershocks)	15210	15240
Efficiency with Accumulated Data	59.67%	61.21%
Monthly Average of Finished Products (1 month = 25 days)	95	98
Average Demand (1 month = 25 days)	160	160
Monthly Average Efficiency	59.38%	61.25%

Source: Self-made



Source: Self made.

Figure 10. Representation of the current system



Source: Self made.

Figure 11. Result of the model indicators

In order to achieve the elimination of the root causes, the indicators for the tools have been proposed, in order to measure their effectiveness. In this part, the current situation (As-Is) is compared with the situation after implementing the proposed improvements. All this is based on the review of the literature previously carried out.

V. DISCUSSION

In the previous study, it was evidenced that during the study time there were losses in utility since 73 units were stopped being produced according to the stoppage time in the months of July 2019 to February 2020. Those reasons that They did not allow to obtain a greater profit in production with the proposed model, so the new economic impact after implementation is as follows:

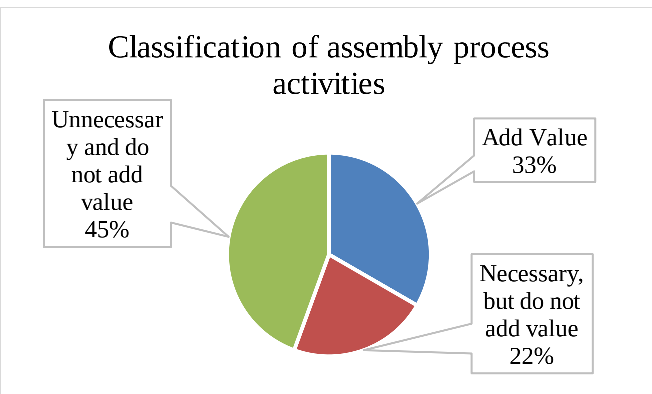
Before the implementation of the improvement, it was obtained that on average, 10 units per month were stopped being produced. After the implementation, these are constantly reduced, so for the first month, the lost profit drops by 28.09%, compared to the monthly average of profit loss in the study time and for the second month by 16.63%, compared to the loss, Of utility in the month prior to implementation.

Prior to the added value analysis, an analytical diagram was made to know the activities of the critical process, that is, the assembly, then identify which are the necessary activities and which do not add value to the final product. The results obtained in the current situation were the following:

Table 6. Assembly processevaluation

Quantitative analysis of the classification results in the assembly process		Add Value	Necessary, but do not add value	Unnecessary and do not add value
Total activities	18	6	4	8
Total activities (%)	100%	33%	22%	44%
Average time of activities	106.47	62.39	2.57	41.51
Total time	100%	59%	2%	39%

Source: Self-made.



Source: Self-made.

Figure 13. Classification of Assembly activities

In the assembly process, it is observed that the time of activities that add value to the product is 62.39 minutes, out of a total of 106.47 minutes. Developing the added value index, 59% is obtained; this means that the process is not effective. Therefore, a new working method will be created that improves this process, as well as the assembly process.

$$IVA(\%) = \frac{TVA}{TT} * 100\%$$

$$IVA(\%) = \frac{62.39}{106.47} * 100\%$$

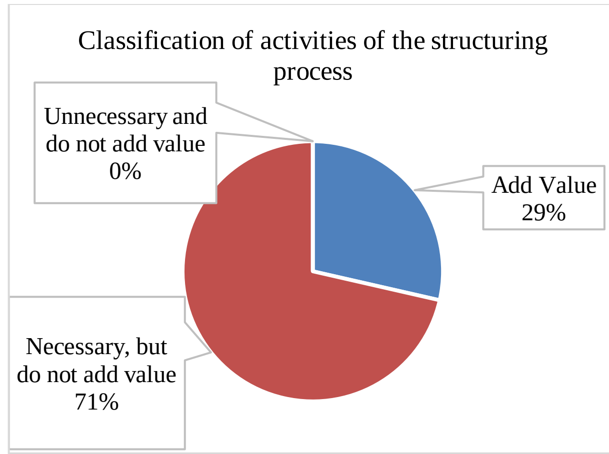
$$IVA(\%) = 59\% < 75\% \rightarrow Ineligible\ Process$$

According to the improvement of the working method, it is possible to establish an effective process, as shown by the results presented below:

Table 7. Evaluation of the proposal for Operator 1

Quantitative analysis of the classification results in the assembly process		Add Value	Necessary, but do not add value	Unnecessary and do not add value
Total activities	21	6	15	0
Total activities (%)	100%	29%	71%	0%
Average time of activities	65.79	50.63	15.16	0
Total time	100%	77%	23%	0%

Source: Self-made.



Source: Self-made.

Figure 14. Classification of process activities - Operator 1

A quantitative analysis of the proposed work method was carried out, which resulted in an added value time of 50.63 minutes out of a total of 65.79. Developing the added value index, 77% is obtained. Therefore, an effective process can be determined.

$$IVA(\%) = \frac{TVA}{TT} * 100\%$$

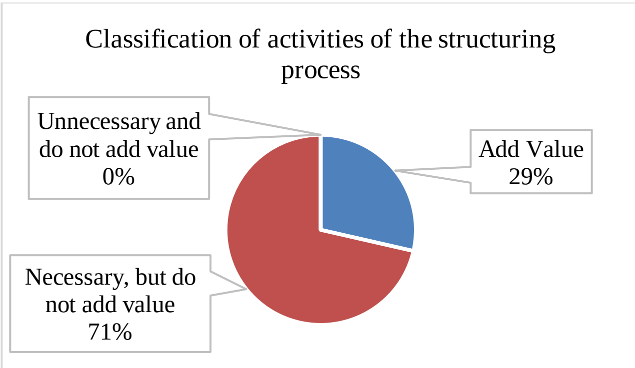
$$IVA(\%) = \frac{50.63}{65.79} * 100\%$$

$$IVA(\%) = 77\% > 75\% \rightarrow Effective\ Process$$

Table 8. Evaluation of the proposal for Operator 2

Quantitative analysis of the classification results in the assembly process		Add Value	Necessary, but do not add value	Unnecessary and do not add value
Total activities	14	4	10	0
Total activities (%)	100%	29%	71%	0%
Average time of activities	65.05	58.89	6.16	0
Total time	100%	91%	9%	0%

Source: Self-made.



Source: Self-made.

Figure 15. Classification of process activities - Operator 2

Through the quantitative analysis of the proposed work method, a value-added time of 58.89 minutes was obtained out of a total of 65.05. By calculating the value-added index, 91% is obtained, which means the effective process can be determined.

$$IVA(\%) = \frac{TVA}{TT} * 100\%$$
$$IVA(\%) = \frac{58.89}{65.05} * 100\%$$
$$IVA(\%) = 91\% > 75\% \rightarrow Effective\ Process$$

Compared to the current method, it was possible to combine the processes and create a workstation, which will be executed by 2 operators. With the implementation of the SLP, 5S, and SW, the production time in the structuring station has been considerably reduced, the process taking approximately 66 minutes, which represents a 65% reduction in production time.

VI. CONCLUSIONS

In conclusion, the implementation of the proposed model achieves the objective of increasing productivity by reducing production time by 42% so that the units to be produced increase from 78 to 98 upholstered furniture. As a result of the implementation, it was possible to regulate the cycle times of each process, identified in the Value Flow Map, achieving that they are below the Takt Time and thus meet the demand. Regarding the Simulation, the transfer times were reduced in% and, by grouping the Assembly, Cutting, and Assembly processes in the Structured station, the efficiency of the process increased by 13%. The feasibility of the project is verified by obtaining a positive net present value and an internal rate of return of 32%.

It is recommended that a thorough review of the plant distribution be carried out in MYPE companies since many of these have a design that has been formed along the way and can be detrimental to the product flow. It is recommended to take into account the company's ability to maintain constant growth and not reach a point where this factor is limiting. Find the necessary resources that allow continuing increasing competitiveness in the market. It is recommended to maintain a budget according to the size of the company where the research is carried out, and different tools can be more effective but expensive.

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