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Original Article

Application of Lean Manufacturing to Improve the Duct Production Process of an Air Conditioning Company in the Year 2021

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Abstract *- The article's objective was the implementation of the lean manufacturing methodology in the production process of an air conditioning metal processing plant. For this, the methodology of 2 phases was used. The company and its current operation, structure, products, and work plan are presented in the first phase, demonstrating its main deficiencies. In phase 2, an improvement plan was made with lean manufacturing tools applied to the deficit of phase 1. As a result of the implementation of these tools, 64%, 80%, 71% and 50% of space in the measuring, cutting, bending, and welding stations, respectively, and an improvement in production times were obtained. Based on the study results, it is concluded that the application of lean manufacturing benefited the company by drastically improving its production process and work environment.*

Keywords *- Value stream mapping, Kanban, Productivity, Process improvement, 5S.*

1. Introduction

In recent decades, global competitiveness has become a confrontation between organizations seeking to obtain the highest profitability and utility based on achieving their objectives. To become competitive in a market, it is necessary to develop a controlled system for the production process to define, ship, analyze and prepare needs through the control of the supply chain [1]. These companies use their available resources to obtain a competitive advantage that helps them stand out from their competitors and position themselves as market leaders. There are companies which have increased by 38. 3% since 2009, reflecting the high competitiveness present in the global market, where customers prioritize product quality at a lower price and with increasingly shorter delivery times; however, a large percentage of these companies do not have a management plan and a work order, thus causing a poor use of resources and loss of time and money [2].

In the country, many companies go bankrupt due to a lack of administration, lack of knowledge in distribution and little experience in management [3]. In Peru, this reality is replicated on a large scale; taking into consideration the large number of small companies and formal and informal Mypes that exist, it could be estimated that an exaggerated number of resources that daily are depleted in waste due to the lack of direction in the execution of the processes that are carried out. For this reason, companies invest heavily in industrial research and development every year. The large companies present a diversity of products, minimum costs, and more information in movement, which are a reliable selection for the lender because they see a high possibility of profitability". In the search to develop and apply a methodology that helps entities to gain an advantage over their competitors [4].

Currently, in Peru, a large percentage of these companies do not have a management plan and a work order, thus causing a poor use of resources and loss of time and money. In Peru, many companies go bankrupt due to a lack of administration, lack of knowledge in distribution and little experience in management. In addition, considering a large number of small companies and formal and informal Mypes that exist, it could be estimated that an exaggerated amount of resources are wasted daily due to the lack of direction in the execution of the processes that are carried out and lack of methodological experience. For that reason, in the present 2021, it is observed that the new Peruvian companies do not

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achieve their main objectives in the determined time, and this is generated by several factors that cause the appearance of waste within the work center, such as disorder, reprocesses, wastes and among others. This reality occurs mostly in companies that lack methodological experience and therefore do not apply a specific work method that allows them to solve the problems of organizational functioning [5].

Research papers in the literature employ various problem-identification tools and methodologies for direct application in study environments. One of the methods with the highest rate of benefits is Lean manufacturing [6]. The study papers [7-12] described works applied to other industries based on using lean manufacturing methodology to solve operational performance problems. The results achieved with the lean manufacturing methodology are encouraging and allow companies to promote organizational change with an effective roadmap.

In [13,14], they mention the usefulness of the lean manufacturing tool and its benefits. It offers for a production system should be known if a business wants to increase its income and profitability. It will be necessary to improve the relationship with customers, in which they will have to grant good quality products, lower prices, shortening changes and response times. For this reason, it is considered a powerful tool for continuous improvement and optimization of business resources. In order to adopt this methodology, we must consider certain important aspects such as, for example, the time available to the organization for the implementation of this methodology, have the necessary resources such as financial, human, material, and others. To obtain success in its implementation and in the results [15,16,17].

This demonstration of lean manufacturing emphasizes the possibility of generating a continuous improvement plan and empowering small companies that have been emerging during the last 10 years. According to [18,19] mentions that lean manufacturing is an option that demonstrates its flexibility when implemented in the different situations of the analyzed sector. Therefore, it is believed convenient that a company should use these tools since they allow to increase productivity in a company and thus achieve organizational objectives. Likewise, [20,21] mentions that, in order to implement the lean manufacturing tool, one should start with the 5S methodology and then continue with the other tools. Therefore, the motivation proposed by the authors is to demonstrate that, by performing the correct application of the lean manufacturing methodology, it is possible to obtain favorable results for the continuous collective development of the entire organization.

The proposed solutions use similar tools in different application scenarios from the articles presented, indicating their benefit. However, they do not make a specific comparison for each element or problem identified in the company, taking into account the particular benefit of optimized improvement.

In this context, the objectives of improvement of the enterprise resources of the company in the industrial sector are proposed with the help of lean manufacturing management tools. Within the different deficiencies that the company under study can present, it is considered important to improve the conditions of the production process of air conditioning ducts in its different processes. The method used for this case was based on the methodology described in [22], which is based on the evaluation of lean manufacturing tools to be applied with the help of the methodology known as 2 phases. The organization's current state is raised in the first phase, and in the second phase, the improvement plan. Next, we will evaluate in depth the applied methodology, the variants, and the results of the same developed for our research work.

2. Methodology

This section details the steps to be carried out for this research. Based on the quantitative methodology of applied scope, used in [22]. Which divides the research process into two phases (see Figures 1 and 2). These present the following stages.

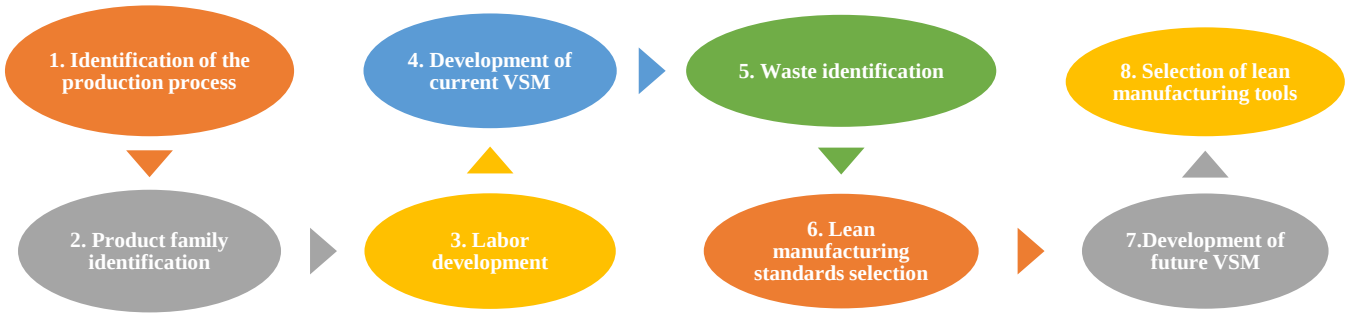


Fig. 1 Phase 1 – Analysis and diagnosis.

Fig. 2 Phase 2 - Improvement proposal.

Phase 1 seeks to analyze the current situation and the operation of the company; it will begin by identifying the production process through which all the company's products pass, the vast majority of these share the workshop machines, so it is essential to know their similarities and classify them by product family, in order to improve a set of materials. As part of the information analysis, it is necessary to use the general labor development of the company, the time of daily hours, snack time, maximum production, production rate and other data. This will be important for developing the value stream map (VSM). This tool allows us to observe the company's total operation, identifying waste, time losses and other flows within the current operation. Thus, it is possible to obtain performance indicators that will demonstrate the benefits of lean manufacturing. With the data obtained from the current value stream map, we will be able to classify the best lean manufacturing tools to solve these wastes. At this point, it is important to know each lean manufacturing tool to select the one that best suits the needs of the problem. With this information explained in Phase 1 (see Figure 1), the application of Phase 2 (see Figure 2) is implemented, which has procedures in the following sections.

In phase 2, the application of lean manufacturing will be carried out with the best classification among them. This tool should be applied throughout the production process in order to obtain general results that improve the data obtained in phase 1. In this way, observing the improvements obtained from lean manufacturing will be possible.

The phases mentioned above will be developed to apply the methodology in the company.

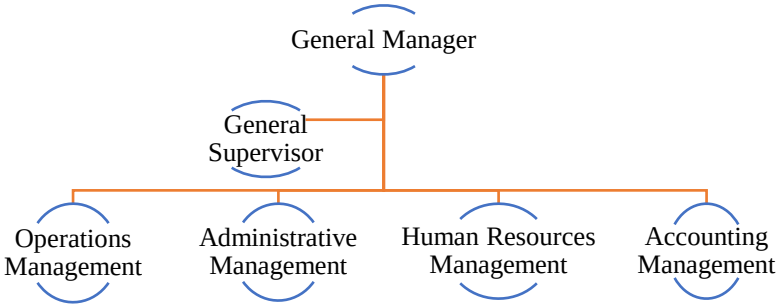


Fig. 3 Company organization chart

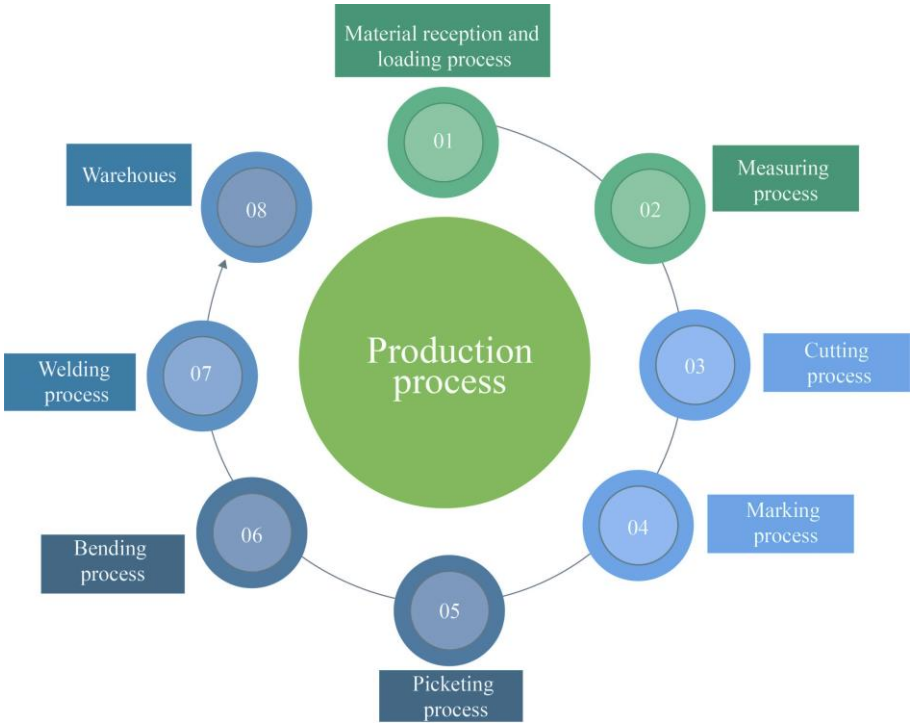


Fig. 4 Production process

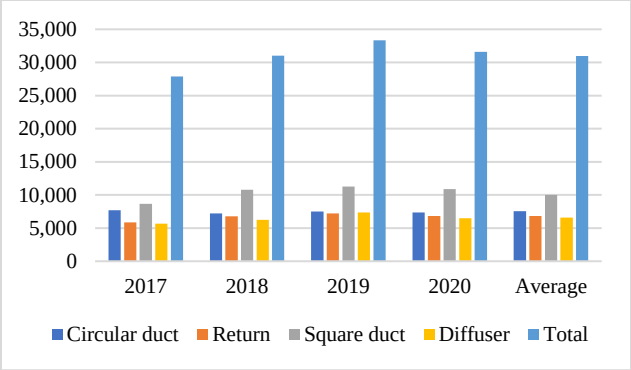


Fig. 5 Historical demand

2.1. Phase 1: Analysis and Diagnosis

The analysis of this study is based on a company belonging to the production of materials and air conditioning ducts. This company has 4 production lines in its workshop located in Comas (circular duct, square duct, return and diffuser). This company's vertical organization chart is distributed as follows (see Figure 3).

The production lines on the shop floor are defined by the type of shape and finish required to meet the request of the operating area in the field. The following box will show the simplified activities that every product on the company's shop floor will have to go through (see Figure 4). According to [30], this is a tool that allows providing value to the activities, waste of materials, waste of information flow and use of people. Likewise, the figure shows the different suppliers and production processes, thus observing a large volume of delay in processes 01 and 02. Following this, it is important to calculate the production rate.

The next step is to specify the wastes found within the current value stream map and previously seen process diagram (see Table 2).

Following this, lean manufacturing standards will be selected to determine the metrics or indicators that will allow us to reach the future state of the value stream map. This should be achieved by measuring indicators in the production system.

An important indicator is an average time to failure or also known as MTBF, which will help us to identify the relationship between the number of working hours of each machine and the number of failures that it may present during a certain period of work. Additionally, the breakdown repair time indicator for each machine, known as MTTR (acronym in English), is used. This Kpi will allow us to know the time used to restore the operation and related to the number of failures in a given period (see Table 3).

The product family to be studied for the present case will be the one that obtained the highest average demand during the years 2017 to 2020 in the company (see Figure 5).

The company presents the following general development, showing total time, demand, production rate and time available (See Table 1).

It is very important to know the current status and situation of the product family we are going to focus on. For this reason, the current value stream map (VSM) development is shown (see Figure 6).

Table 1. Company development

Variable	Outcome	Measure
Workday	9	Hours
Lunchtime	1	Hour
Number of shifts	1	Daily
Days per month.	22	Days
Monthly demand	462	Units/month
Available time	8	Hours
Available time	480	Minutes
Available time	28800	Seconds
Daily demand	21	Units
Production rate in seconds	1371.43= 1372	Seconds/unit

Table 2. Waste identification.

Waste	Description
About production	• Accumulation of products in the stations due to disorder. • Lack of planning with respect to active projects. • Excessive occurrence of molting and waste due to the clutter in the work area.
Transportation	• Transfer of finished product to the storage area (floor 2). • Unnecessary movements to look for work tools.
Waiting time	• As there is only 1 machine of each type, operators are waiting for the release of each machine.
Inventory	• Finished products are kept in inventory until the specialist requests them. • Lack of space delimitation for each type of product in the warehouse.
Unnecessary movements and activities	• Time lost searching for primary tools. • Time was wasted searching for EPPS for the use of each machine. • Time wasted in searching for the user's manual for each machine.

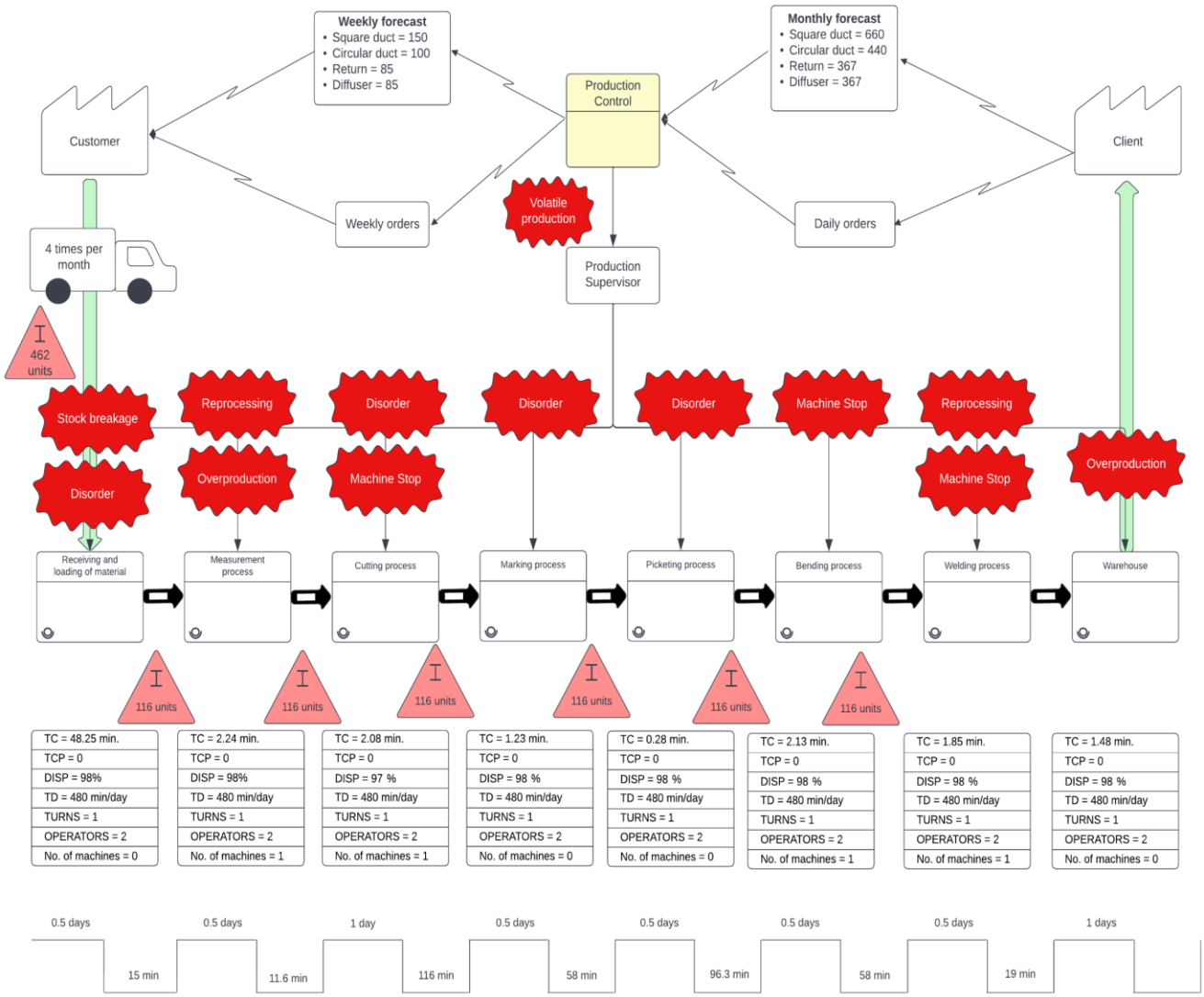


Fig. 6 Current Value Stream Map (VSM).

Table 3. Company's monthly MTBF and MTTR.

Machine	MTBF (hours)	MTTR (hours)
1. Bending machines	37.5	2.60
2. Cutting machine	17.5	0.815
3. Spot welding machine	72	9.14

For this metric, the following formula should be used 1 and 2.

$$MTBF = \frac{Total\ operating\ time}{N°\ of\ failures} \quad (1)$$

$$MTTR = \frac{Total\ time\ to\ repair}{N°\ of\ failures} \quad (2)$$

Another fundamental indicator that will help us to know the company's current performance in terms of scope is the well-known OEE. This allows us to evaluate the overall efficiency of the equipment involved in the production system of the company's pipelines. For this evaluation, it is necessary to perform the following calculation.

$$OEE = Availability \times Speed \times Quality \quad (3)$$

$$OEE_{D.Circular} = (88.89\%)(80\%)(93.75\%) = 66.67\%$$

$$OEE_{D.Square} = (88.89\%)(83.33\%)(32\%) = 68.15\%$$

$$OEE_{D.Diffuser} = (88.89\%)(70.58\%)(83.33\%) = 52.28\%$$

$$OEE_{D.Return} = (88.89\%)(76.47\%)(84.62\%) = 57.52\%$$

Table 4. Target metrics.

Indicators	Start	Target
MTTR	4.19	3.35
MTBF	42.33	33.86
OEE	61.16%	70.33 %

With the evaluation obtained, a future value flow map was developed. The possible lean manufacturing tools that can be applied to eliminate and/or depower the deficiencies and wastes of the company's current operation were recorded (see Figure 7). With the future value stream map and the current conditions of the company, it will be possible to establish improvement objectives with respect to the lean manufacturing indicators previously carried out (see Table 4).

With what was expressed in the previous point, the possible lean manufacturing tools that will be possible to apply for the present work can be indicated. The frequency of wastes found was disorder (53%), machine stop (20%), overproduction (13%) and reprocesses (13%). In view of this, the possible tools that will provide a solution to the above-mentioned problems will be placed (see Table 5).

Table 5. Lean manufacturing tool vs defects.

Tools	Clutter	Machine downtime	Overproduction	Reprocessing
SMED		X		X
JIT		X	X	X
TPM			X	
5S	X	X	X	X
KAIZEN	X		X	
KANBAN	X	X	X	
Standardized work				X

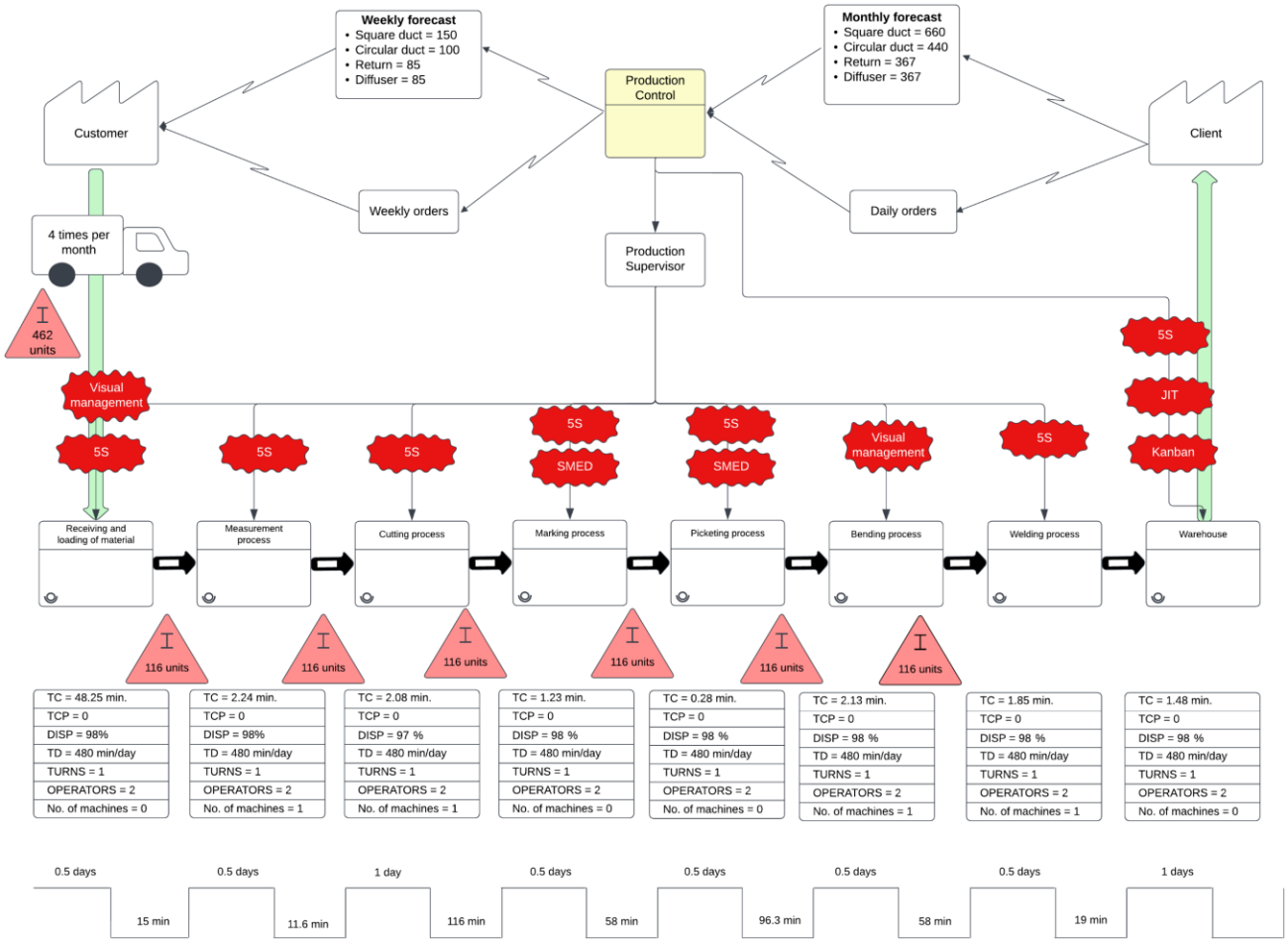


Fig. 7 Current Value Stream Map (VSM)

2.2. Phase 2: Proposal for Improvement

In this phase, the information mentioned above will be used to perform the corresponding application of the lean manufacturing tools according to the analysis to achieve the objectives set out in the indicators. Next, the application of lean manufacturing tools, 5S and Kanban, will be described.

The model proposed as the red card (see Table 6) will be applied in the first S, known as Seiri, which means in Spanish "selection". It seeks to classify the objects to be used in the company's workstations, to know the degree of usefulness and relevance of these objects in the different spaces within the workshop, and to obtain a correct distribution of the elements. In this way, the supervisor, in collaboration with the operators, will be able to classify the tools and equipment necessary for each area with their previous authorization. According [24] mentions that all the elements catalogued as unnecessary should be identified with a red card and eliminated. Following this, the second S was applied, called Seiton, which means "Order". The purpose is to arrange the objects logically at the utilization level at the workstations. To do this, it will be necessary to position the work objects based on an order table (see Table 7).

Table. 6 Red Card

5S RED CARD			N°:
Object name			
Station			
Date of revision			
CLASSIFICATION			
	Machine		Raw material
	Tool		Final product
	Others:		
STATUS			
	Useful		Obsolete
	Defective		Broken
	Unnecessary		Others:
CORRECTIVE ACTION			
	Eliminate		Maintain
	Relocate		Recirculate
	Repair		Others:
Motive:			
Name			
Signature			

Table. 7 2S - Element proximity card

Element:		
Level of use	**Position**	**Brand (x)**
No use	Delete	
At all times	With the operator	
A few times a day	Near the operator (cashier)	
A few times a week	Inside the shelf	
A few times a month	In the warehouse	

Fig. 8 Measuring, marking and picketing area

Fig. 9 Cutting station

With respect to the next S, which is called Seiso, which means "cleanliness", its objective is to maintain cleanliness at the beginning, during and at the end of the workday. For this reason, it is important to determine the areas with the highest occurrence of waste and scrap and the spaces in which metal, aluminum, tools, and other residues may accumulate. Information provided by the manager made it possible to determine the areas with the highest percentage of waste in the workshop.

The area with the highest percentage of residue is the measuring, marking and picketing station (see Figure 8). The next station with the highest percentage of the waste is the cutting station (see Figure 9).

Within the stations, residues can be observed, which will be classified by using the following abbreviations:

1) Cutting residue (RC): This element should be eliminated after the cuts made on the metal.

2) Cleaning residue (RL): This element shall be eliminated when the measuring, marking and picketing processes are completed at the station.

3) Tool residue (RH): This element is located inside the tool drawer and should be removed at the end of the working day.

In order to achieve an orderly and correct cleaning, a container for the waste classified above will be implemented at each of the workstations. One of the operators in the workshop must manage this to ensure compliance as a fourth process within the application of 5S is the Seiketsu, which seeks to standardize the habits implemented in the first 3 uses as a regular way of working. To achieve this purpose, the supervisor in charge will be responsible for implementing them in all workstations.

This person will delegate activities to the operators to expand their knowledge of the 5S. Also, to maintain the correct 5S guidelines, a compliance form will be used (see Table 8). This indicator will be very helpful in measuring compliance at the end of the workday.

Table 8. Check List

CHECK LIST			
Responsible:		**Date:**	
N°	Activities	**Time:**	
1	Cutting station	F	P
	Remove residues from machinery		
	Clean area		
	Check machine (condition)		
2	Bending station	F	P
	Remove waste from machinery		
	Clean area		
	Check machine (condition)		
3	Welding station	F	P
	Remove waste from machinery		
	Clean area		
	Check machine (condition)		
4	Main table (marking and picketing)	F	P
	Remove debris from the table		
	Clean area		
	Distribute tools		
5	Shelf	F	P
	Remove debris from the shelf		
	Clean area		
	Distribute tools on the shelf		
6	Warehouse	F	P
	Remove waste		
	Clean area		
	Distribute raw material/finished product		
	Total		
F	Finalized		
P	Pending		

Table 9. Training and audits

5S module	Sessions	Objective
1S	1	60%
1S	2	100%
2S	3	20%
2S	4	65%
2S	5	100%
3S	6	25%
3S	7	60%
3S	8	100%
4S	9	30%
3S,4S Y 5S	10	50%
4S Y 5S	11	65%
4S Y 5S	12	100%

In this last S, called Shitsuke, also known as discipline, seeks to achieve habits and ways of working that follow the guidelines of the 4S mentioned above. All personnel working within the company must maintain discipline and awareness of the benefits of applying the 5S. With the passing of time, the objective will be achieved by applying various internal and external workshops on the scope to which the company can reach. Also, everything written during the previous 4S should be placed in a report, easily accessible, to obtain the guidelines and policies of operation in the workshop to avoid unknown terms or misuse of the 5S.

To achieve a correct application of the 5S in the company, it is necessary to carry out a training schedule and internal and external audits for the workshop workers. Each of the 5S should be explained in different training sessions, in which the procedure for change, the scope and the physical and mental modifications of the work are explained. By means of this, it is sought that the operators present easy and fast adaptability to the methods proposed by the 5S. The audits and pieces of training will have an evaluation of theoretical knowledge and also practical knowledge, which will have a range of time, which will allow obtaining a visualization of the understanding and performance of the personnel on the influence of the meetings (see Table 9).

3. Results and Discussion

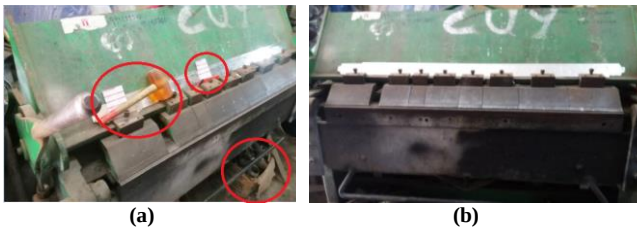
The application of the tools mentioned in the methodology section has provided a purpose of application to the company's workshop.

(a) **(b)**

Fig. 10 (a) Operator filling out a red card; (b) Cards placed in the elements

(a) **(b)**

Fig. 11 Result of the application of the 1S in spot welding, (a) before and (b) after



(a) (b)

Fig. 12 Result of the application in the 1S on the bender, (a) before and (b) after.

In the first "S" called Seiri or selection, the application of the tools within the workshop was carried out by recording information on the elements in the red cards with the support of the operators to identify the usefulness of the machinery, tools, materials and/or products within the workshop (see Figure 10).

After the application of the red cards inside the workshop, it was possible to identify elements within all the workstations that were poorly placed, for their respective elimination of the elements, with the support of the operator in charge, Alexander Prieto, who was in charge of moving the elements of the spot welding and bending stations (see Figure 11 and 12).

At the time of applying the so-called red cards or alert cards, elements were repositioned according to their condition of use within the workshop (see Figure 13); this generated a visual improvement in terms of space, which meant an improvement in the achievement of production process times.

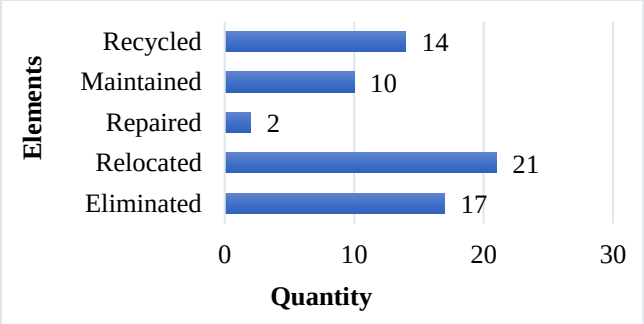
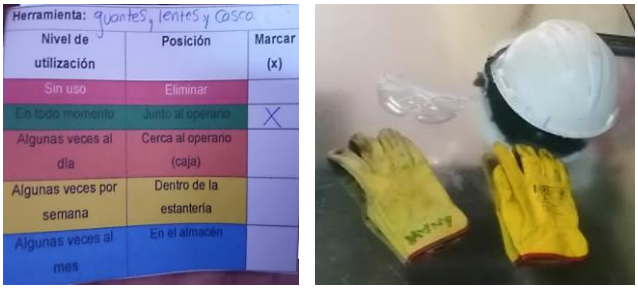


Fig. 13 Results of the 1S

Following this, the application of the second "S" called Seiton or order was carried out (see Figure 14). The results obtained were as follows (see Figure 15) [25].



(a) (b)

Fig. 14 Result of the application of the 2S

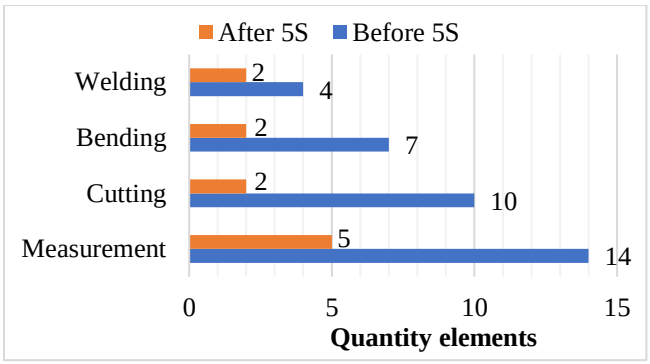


Fig. 15 2S Results

In addition, it was determined that, with the help of the space freed up, an increase in operating speed was also obtained (see Figure 16).

After the application of Seiton, an increase in space within the workshop stations was achieved, as well as a better distribution of objects and a reduction in time.

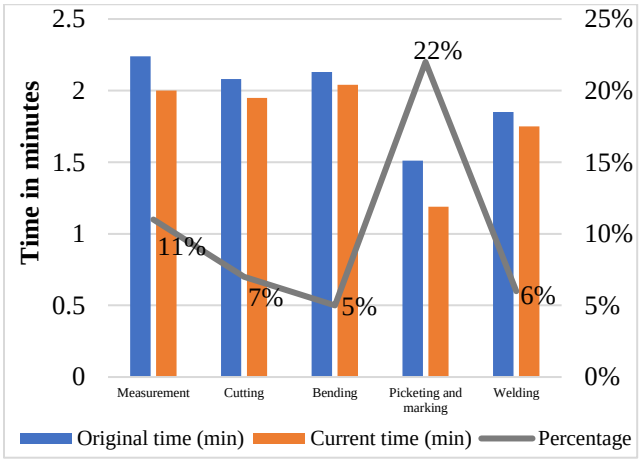


Fig. 16 2S Space freed by applying 2S.

Applying the third "S" Seiton or cleaning in Spanish, an increase in cleanliness was obtained in the workshop due to the incorporation of waste containers inside the premises (see Figure 17). The use of the waste guide helped the collaborators to have knowledge of what is considered waste and residue. The waste containers were strategically placed in the workshop in order to provide ease of cleaning in any space of the station.

(a) (b)

Fig. 17 3S result, (a) before and (b) after.

It can be seen that with the application of the containers, we have achieved greater cleanliness and order in the waste generated by daily production. This has allowed us to improve the working conditions for the operators.

The fourth S Seiketsu, or standardization, has allowed us to generate an improvement in the way of daily work, obtaining the following results (see Figure 18).

With the daily control cards, it was observed that on October 05/10, there was a large number of pending activities and an influx of completed ones; with respect to October 12/10, there was an improvement where 11 activities were completed and 7 pending of the total list. Following this, on October 14, great progress was observed in terms of activities completed. This indicates that we obtain results when the application of the fourth "S" is managed with constancy.

(a) (b) (c)

Fig. 18 Result of the 4S. (a) Date 5/10/21, (b)12/10/21 and (c) 14/10/21.

Regarding the last "S", it was in charge of defining if the previous methodologies had been correctly applied. For this, it was necessary to define different habits such as: 1) Promote and encourage commitment through the use of dynamic theory, methodology and chaining the concepts of the 4 predecessor "S". 2) Promote repetitiveness through the execution of common tasks periodically, in order to provide workers and managers with a greater familiarity with the methodology. 3) To carry out graphic and dynamic executions of the application of activities to be performed in order to follow the correct line of the 5 "S".

After placing several graphic slogans in each part of the workshop to influence collective motivation, we proceeded to establish differentiated objectives for each worker. This, in order to give them a daily, weekly and monthly goal, which allows them to have a greater integration between people since among workers can help collectively to achieve the objectives and thus be important in the success of the 5 "S", this motivation will also be influenced economically by the organization, which will grant economic benefits, rest days or reduced working hours as part of the plan of the discipline plan.

Finally, training is provided to workers, giving them the knowledge and resources they need to perform their work safely and comprehensively. For this reason, training meetings and audits were held periodically. 1) Explaining and reinforcing the knowledge of the 5 "S" methodology. 2) Reviewing the learning methodologies. 3) Review of the objectives carried out individually and in groups. 4) Increase the use of worker-general communication channels. 5) Delivery and communication of the benefits earned by each employee.

Once the monthly programs have been carried out and fulfilled, the follow-up should not be left to those in charge but should be continued in order to prevent it from being only a temporary operation and becoming an empirical one.

The meetings and audits were carried out by external personnel, senior management, as well as regular workers, who used these spaces to provide recommendations for the operation of the workshop. At the end of each meeting, there was an oral and written evaluation of the knowledge obtained and the objectives achieved. The delivery of pocket manuals allowed them to review what they had learned in each session.

With the completion of the last session of the 5 "S" and the evaluations made to each worker, the following results were achieved (see Figure 19).

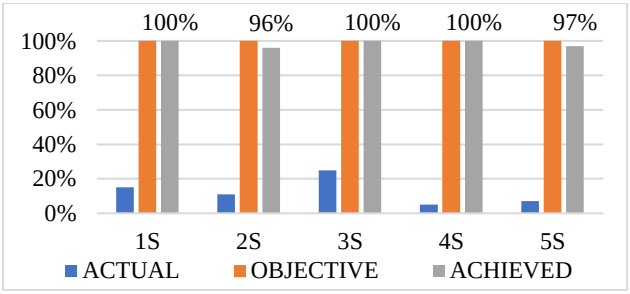


Fig. 19 Audit learning

In Figure 19, it is shown that a high learning rate was achieved among the workers and the company's management.

Together with the evaluations carried out, at the end of the evaluations, we sought to collect the feelings of the workers with the 5 "S", where it is mentioned by one of the workers that "The application of the 5S has allowed us to generate a more responsible work environment that over time will help us to improve as an organization" Also another worker mentions that, "The 5S helped us to optimize our production process, everything looks more orderly and clean, it is our responsibility to maintain this environment".

The statements observed are a clear and notorious example that the 5S tool can be applied in the workplace and replicated in everyday life and in each person's home. After the monthly sessions and the corresponding evaluation, it has been possible to observe an improvement in the way of working, production and work environment achieved by the correct application of the 5 "S" within the air conditioning workshop of the company (see Figure 20).

(a) (b) (c)

Fig. 20 Result of the 5S tool. (a) Cutting area, (b) Operator working and (c) Main table.

All the above evaluation has been of great support to clearly observe the improvements obtained after the application of the 5S with respect to the objectives set out in phase 1 of the methodology. The order obtained by the application of the red cards and the distribution of elements by frequency of use has reduced the rate of stoppages of the semi-automated machinery since, by achieving a more orderly and cleaner work environment to work in, the following is achieved: 1) A wide and total use of the space needed by the machinery in use for its correct operation. 2) Better repair times by having the maintenance elements correctly distributed. 3) Less time spent searching for tools or raw materials.

The overall shop floor efficiency indicator, or OEE, also achieved an increase in overall productivity, daily available production, speed, and efficiency. 1) The operators have the necessary elements to produce at all times.2) The raw materials are in good condition due to the orderly and clean storage. 3) The tools are correctly classified and placed in the stations where they are required.

The implementation of the 5 "S's" has directly influenced the indicators defined during the first phase of the methodology; these have modified the work habits and behavior within the work center. On the other hand, the quantitative evaluation obtained the following results after implementing the 5 "S" (see Table 10).

Table 10. TBF and MTTR post 5S.

Machines	MTBF (hours) after 5S	MTTR (hours) after 5S
Bending machine	56.25	2.35
Cutting machine	30	0.8742857
Spot welding machine	108	6.115
Time:	65	2.330

From Equation 3, the following results are obtained.

$$OEE_{D.Circular} = (88.89\%)(90\%)(100\%) = 80\%$$

$$OEE_{D.Square} = (88.89\%)(93.33\%)(96\%) = 79.64\%$$

$$OEE_{D.Diffuser} = (88.89\%)(82.35\%)(100\%) = 73.20\%$$

$$OEE_{D.Return} = (88.89\%)(82.35\%)(92.31\%) = 67.57\%$$

The results obtained after the implementation of the 5 "S" are correctly favorable and usable with the proposed objectives because it was possible to achieve an improvement in the MTBF index from 43 hours per machine breakdown to 65 hours per machine breakdown; likewise, in the MTTR it was possible to go from 4. 19 hours per repair to 2.33 hours per machine repair, a reduction of 55% was achieved. Finally, the overall effectiveness indicator or OEE increased from 61.16% to 75.10%, representing an improvement in total productivity. This result of the application of the 5 "S" is similar to that also presented in [22], which obtained an improvement of 268%, 22% and 25% of MTBF, MTTR and OEE, respectively. In this way, in [22] were able to demonstrate that the methodology used is beneficial in nature for different organizations in today's markets. It is important to highlight and replicate that, according to the authors, it is necessary to perform a correct evaluation of phase 1 in order to be able to solve potential deficiencies and achieve great differentiation. At the beginning of the explanation and application of the methodology to be applied, there was a negative response from the operators due to the difficult "adaptability to change"; however, after the application and the benefits demonstrated, they showed a better attitude and work expectations.

4. Conclusion

It is concluded that the initial problem of this article was solved, and the conclusions are presented in the following points:

1) a more orderly, cleaner, and faster production process has been presented, this shows that the tools of lean manufacturing are effective in different scenarios of the work environment. 2) The method applied by [22] and replicated in this article has shown great adaptability and improvements with respect to its correct application. 3) It was possible to improve 62% the distribution of elements and the way of working by the collaborators of the companies. In addition, the contribution provided is that in order to maintain the methodology and its success, it is necessary to have the full support of the workers and the general management since they are in charge of carrying out the daily activities and providing the necessary resources for the correct development of the same. 4) The implementation of the 5 "S" achieved an increase in the average machinery breakdown rate (MTBF) within the workshop, with an improvement of 51% with respect to the initial analysis. It was also possible to decrease the rate of recovery hours for a machine in the workshop, decreasing the 4.19 average hours of machinery recovery to 2.33 hours. Moreover, the overall effectiveness index (OEE) increased from 61.16% to 75.10%. This improvement of 13.94% was achieved by the commitment presented by workers and managers after each session of the 5 "S" methodology.

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