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Application of Lean Manufacturing to Increase Productivity in the Finishing Area in an Industrial Rubber Company

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Abstract

This research work sought to apply the Lean Manufacturing methodology, with the purpose of improving productivity in the finishing area of a rubber company. It has been observed that, in this area, there is a low productivity, due to an absence of a culture of order and cleanliness, and a lack of production control. The application of Lean tools showed a substantial increase in productivity (from 56.47% to 75.86%), this achieving a progress of 34.33% in the finishing area. In addition, in relation to efficiency, the use of average man-hours will be improved from 75.30% to 87.90%, resulting in an improvement of 16.74%. And, according to the efficacy, an increase was found in the quantities produced, on average, which went from a value of 74.99% to 86.3%, this resulting in an increase of 15.07% in the production of 3S 200 mm rings.

Keywords:
Lean Manufacturing; 5S; Kanban; Productivity and Rubber industry.

1. Introduction

The rubber industry is one of the main sources of natural rubber. This element is an indispensable raw material used for the manufacture of more than 40 thousand products (anti-slip flooring, surgical gloves, among others) in the medical device and automotive industries. In recent years, due to the increase in operating costs in rubber plantations, the low availability of labor, and unfavorable environmental conditions, as evidenced in global trends, the production of items using this raw supply have been affected. This results in an unfavorable impact to maintain, in a sustainable way, the productivity registered in the rubber industry (Rojas et al. 2017).

At the national level, between 2015 and 2017, 63.3% of the companies engaged in the manufacture and commercialization of rubber and plastic products implemented some type of activity within their production processes. In detail, these were the following: (a) the purchase or rental of technological equipment (46.6%), such as machinery or transportation equipment; (b) the acquisition of programs (31.8%), which refers to obtaining some type of software or database; (c) the application of engineering tools (26.4%), such as Kanban or 5S (Instituto Nacional de Estadística e Informática 2017).

Within this framework, the industrial rubber company currently has 28 years of experience in the field and is mainly engaged in the transformation and marketing of rubber for industrial, mining and construction use. In this sense, the 3S 200 millimeters (mm) rings, a product designed for metric dimension pipes, represents a level of participation of up to 92% of the total sales of the business in recent years (Hules Peruanos S.A.C. 2021). In addition to this, the starting point was the fact that, in the finishing area of the company, an incorrect use of resources (time, movements or others), low productivity, incorrect use of man-hours (m-h), presence of obstacles in the access ways, lack of process standardization, disorganization and presence of dirt inside the area were identified. Therefore, these problems end up damaging the quality and production of the main product under study.
To achieve the results of the research it is necessary to perform the following:

- Current analysis of the area using 5S and Kanban as tools of the "Lean Manufacturing" methodology.
- Application of 5S to provide solutions to the problems encountered in the finishing area.
- Measure productivity improvement in the finishing area according to "Lean Manufacturing".

Based on the problems described above, the research seeks to answer: to what extent does the application of Lean Manufacturing improve productivity in the finishing area of an industrial rubber company? And, to what extent does the application of Lean Manufacturing improve efficiency and efficacy in the finishing area? Regarding the objectives, we seek to determine if the application of Lean Manufacturing improves productivity in the finishing area of the firm; if the application of Lean Manufacturing improves efficiency and efficacy in the finishing area. The hypotheses, H_0 regarding the application of Lean Manufacturing increases productivity by ≤13% and H1 regarding the application of Lean Manufacturing increases productivity by ≥13% (Figure 1).

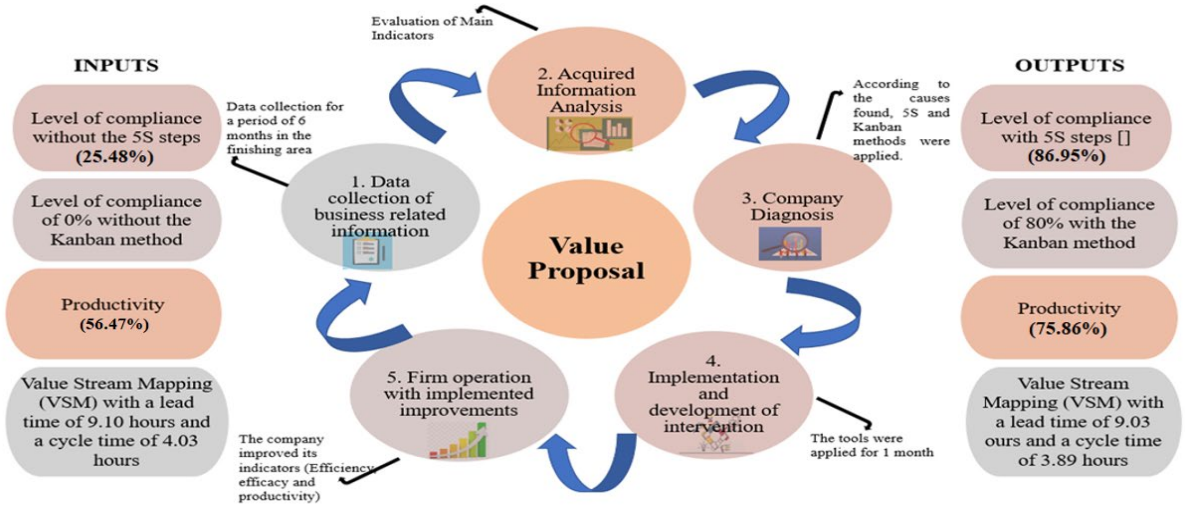


Figure 1. Proposed improvement model

1.1 Objectives

This research aims to determine whether the application of Lean Manufacturing improves productivity in the finishing area of the firm; and whether the application of Lean Manufacturing improves efficiency and effectiveness in the finishing area.

2. Literature Review

The literature review provided a clearer picture about Lean Manufacturing and the 5S to be modeled and implemented in the study. According to Vargas and Camero (2021), it was possible to demonstrate the effectiveness of the application of the 5S tool, reducing the manufacturing cycle time by 3 hours and 6 minutes and increasing productivity by 21.68%. For their part, Socola et al. (2020) applied the 5S to improve productivity in the warehouse area of a banana company where there was an 84% increase. Another example is the case of the international company Nestlé, which applied this work method, achieving improvements in the efficiency of its workers, resources, economy, environment, among others (Lomparte et al. 2022). Another study was on the improvement of the productivity of high volume/low variety automatic machinery of a company belonging to the textile industry in India. As a result of the application of Kanban and 5S, the architecture of the industrial premises was improved, the positions of the frames, cones and columns were improved in such a way that the use of space is optimized, which improved the performance of the machinery and of workers (Mohan-Prasad et al. 2020).

THEORETICAL FRAMEWORK

A. Definition of Productivity

Productivity is linked to the results obtained from a process, activity or system; furthermore, the indicator is defined as the capacity to produce a certain amount of goods or services with a specific amount of resources and that its growth can be measurable through production volumes (Díaz and Toscano 2021).

$$Productivity = Efficiency\ x\ Efficacy \quad (1)$$

Regarding the success cases, Vargas and Camero (2021), who developed their research in seven months, increased production productivity from 4.37 kg/h to 5.58 kg/h; which amounts to an increase of 27.68% (Vargas and Camero 2021). Likewise, Sócola et al. (2020) applied the Lean Manufacturing methodology, increasing productivity in the warehouse area of a banana company, observing great changes in productivity, which increased by 84%. In turn, Salgado and Salgado (2019) used the Lean Manufacturing methodology in the area of External Logistics and Delivery Services of the company Urbano Express, which managed to increase productivity from 69% to 75% in the bank clearing service; and from 80% to 85% in the home delivery service.

B. Definition of the 5S tool

The 5S tool is part of the Lean Manufacturing methodology, its origin is Japanese and it is based on its five stages: seiri (classify), seiton (sort), seiso (clean), seiketsu (standardize) and shitsuke (discipline), which aim to improve the aspects of organization and cleanliness within a work environment; it also creates standards in the processes in an efficient and effective way (Salazar et al. 2022). The application of the 5S tool aims to avoid or reduce deficiencies in a work environment, such as: the presence of dirt in the workplace, tools or others; presence of disorganization in the work area; incorrect use of resources; among others (Olvera et al. 2022).

C. Definition of the Kanban method

Kanban is a Lean method that is responsible for managing and improving the workflow, through control cards in order to ensure high quality and production in a certain time (Arcentales et al. 2022). The following formula was used to calculate the Kanban indicator:

$$Kanban = \frac{Executed\ Control\ Cards}{Elaborated\ Control\ Cards}\ x\ 100\% \quad (2)$$

D. Definition of Efficiency

Efficiency is the capacity of a worker, an activity or a process within a production chain to correctly use resources such as equipment, tools, work spaces, among others, in order to achieve the objectives proposed by a process, area or company (Panduro et al. 2020). The following formula was used to calculate efficiency:

$$Efficiency = \frac{Monthly\ Hours\ Employed}{Planned\ Hours}\ x\ 100 \quad (3)$$

E. Definition of Efficacy

Efficacy refers to the ability to achieve the objectives set or proposed by an area or company; the priority of this indicator is the results obtained from the improvement, implementation or application of some engineering tool for optimization (Cachanosky 2021). The following formula was used to calculate efficacy:

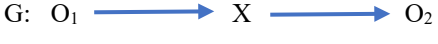
$$Efficacy = \frac{Real\ Production}{Programmed\ Production}\ x\ 100 \quad (4)$$

In summary, the studies by Vargas and Camero, Sócola et al, Lomparte and Mohan-Prasad et al have in common the application of Lean Manufacturing tools, as well as the 5S methodology to increase productivity in different industries. In addition, the contribution of the concepts on the 5s methodology and the Kanban tool described above, allow them to recognize the importance of eliminating waste, optimizing work processes, promoting organization and order, and encouraging continuous improvement to achieve greater efficiency and competitiveness in the business environment.

3. Methods

METHODOLOGY

The type of scientific research was established as applied, in view of the fact that it generates practical knowledge of immediate use. It was also explanatory, since it was intended to find the reasons for the low productivity in the finishing area of the business and, consequently, to create a sense of understanding (Montoya et al. 2022).



Where:

G=Group

O1=Measurement of productivity at the beginning
X=Application of the 5s and Kanban tools
O2=Measurement of productivity after

All areas of the business (die making, pressing, cutting, etc.) were considered as the population and, based on this, the sample was the finishing area, because it required more operation time, generating a bottleneck in the production of rings. The information was collected over a period of 6 months.
The techniques used were documentary analysis and observation. And the instrument was the report card. It should be noted that the techniques and instruments in question involved the use of key materials, such as bond sheets, pens, stopwatches, measuring tools, among others (Machado et al. 2019).

4. Data Collection

In order to have a data collection that is both timely and reliable for the study, the following activities were duly carried out:

- The initial and proposed Value Stream Mapping (VSM) was prepared.
- The Ishikawa Pareto diagram was developed.
- Collection of 5S and Kanban tools was done.
- Data collection instruments were applied to the finishing area.
- Construction of Figures and Tables based on Excel 2021 spreadsheets.

5. Results and Discussion

At the beginning, the finishing area presented a greater time requirement to complete its operational activities, evidencing in indicators such as efficiency and efficacy values of 75.30% and 74.99% respectively. This caused the productivity in the finishing area to be 56.47%. As a result, the Lean Manufacturing methodology was applied to increase productivity and its indicators (efficiency and efficacy) through the 5S and Kanban tools. Subsequently, there was an increase in efficiency to 87.90%, representing an improvement of 16.74%. In efficacy, it increased to 86.30%, representing a % improvement of 15.07%, and finally in productivity, it increased to 75.86%, representing a % improvement of 34.33%. This proves the hypothesis stated in the research, since there was a significant increase (p=0.000). In other words, the application of Lean Manufacturing increases productivity by $\geqslant$13%.

These findings present similarities with other research of the same nature, in which problems related to inefficiencies in the control of production, waste and inputs, as well as problems in the administrative and operational area are observed. Among these is the work of Salgado and Salgado (2019) who increased productivity in the logistics area of an urban company, improving productivity from 69% to 75% in the bank clearing service; and from 80% to 85% in the home delivery service. This generated a 90% profitability in the logistics area (Salgado and Salgado 2019), as well as the work of Sócola et al. (2020) who applied the 5S tool, which improved productivity in the warehouse area of a banana company by 84%, the efficiency was 89% and the efficacy was 94% (Sócola et al. 2020). In addition, the study by Vargas and Camero (2021) mentioned that after applying the lean methodology, there was an increase in production productivity, going from 4.37 kg/h to 5.58 kg/h; that is, an increase of 27.68 (Vargas and Camero 2021). The difference in the percentage of improvement in each of the studies is due to the fact that the investigations always seek to improve their indicators (productivity, efficiency, efficacy, efficacy, etc.) by applying more than one tool such as TPM; Poka-Yoke; Kaizen; 5S and Kanban, etc., all of them with the purpose of improving the processes and in turn increase their production sales. Finally, there is a difference between the results and the visible results in the authors' study because they are dealing with different sectors.

5.1 Numerical Results

APPLICATION OF LEAN MANUFACTURING METHODOLOGY IN THE FINISHING AREA

The application of the following Lean tools was developed, which were 5S and Kanban, in the finishing area of a rubber company, considered a bottleneck that harms the production of 3S 200 mm rings. In addition, it should be noted that the average operation time of this area was 2,612 seconds, which represented in hours (h) is 0.73 h for only obtaining a production batch, considering that a batch tends to 79 3S 200mm rings. For this, the participation of the management was previously requested in relation to training and production personnel for the identification, classification and elimination of those materials or objects that add and do not add value in the processes of the area.

A. Situation analysis of the finishing area

The current VSM of the manufacturing processes of a production batch of 3S 200 mm rings, where the following aspects were considered: cycle times, waiting times, shifts, lead time, reprocessing, wastage and inventories.

Through the value map it was possible to identify the main problems related to the production line of the product under study, since, in the whole company, the cycle time was 4.08 hours and the lead time was 9.1 hours; also, it was observed that the finishing area was the second process that presented a high cycle time, it being approximately 1 hour. After evidencing that the finishing area is one of the areas that presents a high cycle time in the company, besides being related to the lack of a culture of order and cleanliness, as well as a lack of production control, we proceeded with the collection of efficiency, efficacy and productivity indicators.

Table 1. Efficiency and Efficacy in the finishing area before the implementation of Lean tools

Month	Hours spent per month	Number of employees	Days worked per week	Planned hours per month	Actual production	Scheduled production	Efficiency before	Efficacy before
Month 1	114.84	1	5	154	15085	20152	74.57%	74.86%
Month 2	116.16	1	5	154	15152	20152	75.43%	75.19%
Month 3	115.67	1	5	154	15000	20152	75.11%	74.43%
Month 4	116.99	1	5	154	15196	20152	75.97%	75.41%
Month 5	115.72	1	5	154	15107	20152	75.14%	74.97%
Month 6	116.38	1	5	154	15130	20152	75.57%	75.08%
TOTAL AVERAGE							75.30%	74.99%

According to the workday of the workers during the 6-month period, an average efficiency of 75.30% was obtained, in man-hours (m-h) (See Table 1).

Current VSM of the manufacture of 200 mm 3S rings shows as a final result of lead time 9.10 hours and as a total cycle time of 4.03 hours. In the VSM after the implementation, the decrease of both times will be observed.
According to the working day of the workers during the 6-month period, the results obtained after the application of the efficacy formula can be clearly observed, where an average efficacy of 74.99% was obtained.

According to the working day of the workers during the 6-month period, the results obtained after the application of the efficacy formula can be clearly observed, where an average efficacy of 74.99% was obtained. (See Table 1).

Productivity = 75.30% x 74.99% = 56.47%.

It can be observed the results obtained after the use of the productivity formula in the period of 6 months, where it was possible to obtain an average value of the productivity indicator of 56.47%, which is below the productivity found in Salgado and Salgado (2019), obtaining the value of 69%. Therefore, it can be argued that there is low productivity in the finishing area of the rubber industrial company.

B. 5S Tool

In relation to the 5S tool, a diagnosis was previously developed, where all the stages and criteria necessary to evaluate the working conditions of the finishing area were considered.

The Radial Diagram of the 5s at the beginning of the 5s. Shows that before the implementation of the 5S tool, resulted a value of 25.48% was obtained, where the highest compliance was in the cleaning stage with 45.0% and in the last stage was the ordering stage with 7.14%.

C. Kanban Method

Kanban method indicator before its implementation:

$$Kanban = \frac{0\ control\ cards\ executed}{0\ control\ cards\ elaborated}\ x\ 100\%$$

After evaluating the indicators and the 5s and Kanban tools at the beginning. Each of the tools was applied. (See Table 5). Obtaining before the implementation 28.57% in classifying, 7.14% in order, 45% in cleaning, 16.67% in standardizing and 30% in discipline. In summary, after the development of the 5S tool, it allowed a better use of work spaces, time efficiency (h-h) and reduction of displacements, through the elimination of unnecessary objects, the organization of work tools or others and keeping the work area clean. Those aspects applied had a positive impact on the processes, generating an increase in the volumes and production capacity of the area under study.

D. Efficiency

For the development of the calculation of the efficiency of the application of the Lean tools proposed in the study, the working hours used and the hours programmed in the finishing area were evaluated through formula 2. These results are reflected in Table 3. After the implementation of the Lean tools, a significant increase in efficiency was observed due to a growth in the use of resources (working hours) in the finishing area, where initially the value was 75.30%, increasing to 87.90%, obtaining an improvement of 16.74%.

E. Efficacy

Regarding the efficacy after the application of the proposed tools, information was collected related to the quantities produced and the programmed production in the six-month period in the finishing area. For the determination of the efficiency after the implementation, the same procedure was used, where the following results were obtained, which are reflected in Table 2. The results obtained from the efficiency indicator after the implementation of the proposed tools, which is related to the quantities produced (units) of 3S 200 mm rings, increased from an average value of 74.99% to 86.30% with a % improvement of 15.07%.

Table 2. Comparative table of the results obtained from the efficiency and efficacy indicator

Months	Efficiency		Efficacy	
	Before	After	Before	After
Month 1	74.57%	89.30%	74.86%	85.62%
Month 2	75.43%	88.86%	75.19%	85.97%
Month 3	75.11%	87.06%	74.43%	85.73%
Month 4	75.97%	88.09%	75.41%	87.47%
Month 5	75.14%	87.01%	74.97%	86.35%
Month 6	75.57%	87.10%	75.08%	86.63%
Average	75.30%	87.90%	74.99%	86.30%

F. Productivity

For the development of productivity before and after the implementation of the proposed tools, information related to the quantity of kg produced and the man-hours (m-h) for the production of a production batch of 3S 200 mm rings was used.

G. Percentage of improvements in indicators

After the implementation of the 5S and Kanban tools, improvement percentages were developed and analyzed for each of the indicators mentioned. These can be seen in Table 3.

Table 3. Results of efficiency, efficacy and productivity indicators

Indicators	Implementation of Lean tools		Improvement %
	Before	After	
Efficiency	75.30%	87.90%	16.74%
Efficacy	74.99%	86.30%	15.07%
Productivity	56.47%	75.86%	34.33%

In relation to the results obtained for the three indicators under study, we have mainly efficiency, which achieved a % improvement of 16.74%; efficacy obtained a % improvement of 15.07%; and finally, productivity, which obtained a % improvement of 34.33%, so it can be argued that there is an improvement in productivity in the area under study.

H. Proposed VSM

For the development of the proposed VSM, the following modifications were considered in the lead time and cycle time indicators, since the implementation of the 5S and Kanban tool was considered within the scheme. These modifications are reflected in Figure 7. Trough the value map a reduction in the cycle, which was 3.89 hours and the lead time was 9.03 hours; likewise, it was reflected in the finishing area, where the time was reduced to approximately 2,116 seconds.

The result obtained from the current and proposed VSM, in its main indicators, are the following: the leadtime went from 9.10 hours to 9.03 hours and in relation to the cycle time from 4.03 hours to 3.89 hours; it should be noted that these indicators were evaluated for the manufacture of a production batch of 3S 200 mm rings.

I. Hypothesis testing

Table 4. Student's t-test for related samples

Indicators	Application of Lean tools		p-value*
	Before	After	
Efficiency	75.3 ± 0.67	87.03 ± 0.84	0.000
Efficacy	74.99 ± 0.33	86.35 ± 0.89	0.000
Productivity	56.47 ± 0.57	75.16 ± 0.60	0.000

* Student's t-test

H_0: The application of Lean Manufacturing increases productivity by ≤13%.
H_1: Applying Lean Manufacturing increases productivity by ≥13%
The value of 13% was taken as a reference for the hypothesis test, since the three success cases were averaged.

It is shown in Table 4 that productivity, efficiency and efficacy increase significantly (p=0.000), after the application of Lean Manufacturing in the finishing area in a rubber industrial company.

This, the alternative hypothesis (H_1) is accepted as shown in Figure 9.

5.2 Graphical Results

A. Situation analysis of the finishing area

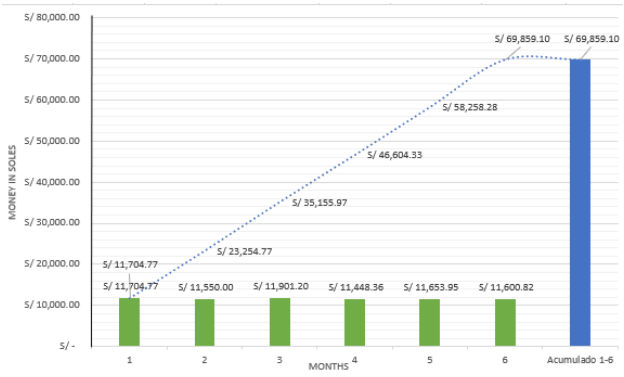


Figure 2. Economic Losses

Figure 2 shows that, in view of its low productivity, the company is limited in achieving its planned monthly production, since an estimate of the economic losses of the product in question for six months would exceed S/69,000.00. It is worth mentioning that these losses would be understood as the potential income from sales if the business had met its expected production level.

After listing each factor that affects low productivity, we went to the company to survey the personnel of the company, which were 13 workers, each of them rated a list of causes, giving their rating to the one they considered as frequent in the finishing area (Figure 3).

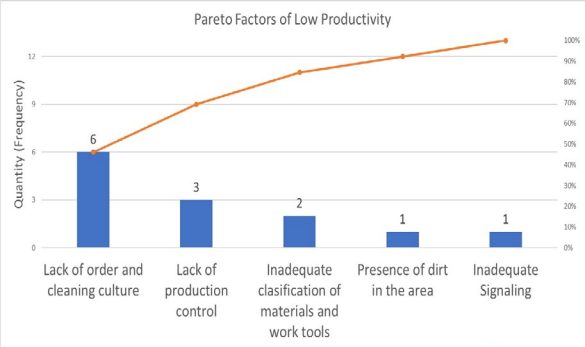


Figure 3. Pareto Diagram

On the other hand, the finishing process within the production chain of a rubber company is the penultimate process, where the burr is removed from the edges of the product to finally be cleaned. Initially, for the collection of information, an Ishikawa diagram was drawn up, detailing the causes that generate low productivity. For the environment factor, one of the causes is the poor conditions of the work area, starting with a lack of cleanliness and order at work and the presence of obstacles in the area. The material factor is the lack of inventory control and poor storage conditions, disorganization of materials and tools. In labor factor, lack of commitment and little communication. In methods, non-standardized processes in the work area and lack of management indicator. Measurement factor as the main cause of lack of internal audits. These are some of the causes that result in low productivity.

Subsequently, proceeded to prepare a frequency table and develop the Pareto chart, as shown in Figure 3, which reflects the 5 main causes that generate low productivity in the finishing area. Therefore, on the basis of the evidence identified, it is chose to apply the 5S tool. Because, through the tool it is intended to increase production and productivity of the area under study in the industrial rubber company.

Secondly, the Kanban method was used, since it is a very useful tool in production control and scheduling systems at different levels, and it allows to visualize, plan and order the activities to be performed in real time. This method consists of establishing a board and the control of control cards, which have these three criteria: to do, which are the activities to be performed; in progress, which are those activities that are in process or waiting; and done, referring to the completed activities.

B. Kanban Method

Kanban method indicator before its implementation:

$$Kanban = \frac{0\ control\ cards\ executed}{0\ control\ cards\ elaborated}\ x\ 100\%$$

$$Kanban = 0\%$$

Figure 4. Evidence before and after the implementation of Lean tools in the finishing area

After evaluating the indicators and the 5s and Kanban tools at the beginning. Each of the tools was applied. It can be said that after the presentation of the results for both situations (before and after), an average value of 25.48% was obtained before the implementation of the 5S tool and that after the implementation of the tool, a growth of 86.95% was obtained (Figure 4).

In summary, after the development of the 5S tool, it allowed a better use of workspaces, time efficiency (h-h) and reduction of displacements, through the elimination of unnecessary objects, the organization of work tools or others and keeping the work area clean. Those aspects applied had a positive impact on the processes, generating an increase in the volumes and production capacity of the area under study.

For the development of the Kanban method in the finishing area, a space was required to establish the control board, the control cards, the elaboration of production records, the bedbugs, training to the responsible personnel and to those in charge of the area under study. First, a schedule of activities was drawn up for a period of 6 weeks, during which personnel were trained on the method, the steps to be implemented and the periodic evaluation of the method.
The results obtained after the application of the Kanban method during the two weeks, a total of 40 control cards (production records) were developed and completed; in addition, 8 control cards were identified as being on standby. For the evaluation of the Kanban method indicator, the total number of control cards produced and the total number of cards executed in an average workday were used. This made it possible to better organize the production of the 3S rings, as shown in Figure 5.

Figure 5. Design and application of the control card – KANBAN

On the other hand, Figure 6 shows the radial diagram after the implementation of the 5S tool, where an average value of 86.95% was obtained, where the highest compliance was in the sorting stage and clean with 90% and the classifying stage with 82.14% being the lowest of the results.

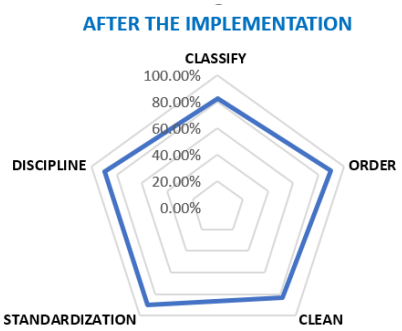


Figure 6. Radial diagram of the 5s after implementation

Kanban method indicator after implementation

$$Kanban = \frac{40\ control\ cards\ executed}{50\ control\ cards\ elaborated}\ x\ 100\%$$

$$Kanban = 80.00\%$$

As a result of the application of the Kanban indicator, a value of 0% was obtained before the implementation of the tool, since the production and finishing areas did not have records or control cards. On the other hand, after the implementation of the Kanban method, a value of 80% was obtained (see table 2), which indicates that there is a better control of the quality and production of the 3S 200 mm rings in the area under study. In summary, the application of the Kanban method allowed better control of the production and quality of the 3S 200 mm rings through the production records issued by the area, the control cards and the Kanban board.

In addition, to carry out the measurement of the impact of Lean tools in the finishing area, the cards, the stopwatch, among others, were used. Through these instruments it was possible to identify and record the production volumes generated and the man-hours (m-h) employed in the six-month period, which were used to develop the calculation of productivity, efficiency and efficacy of the finishing area.

C. Percentage of improvements in indicators

After the implementation of the 5S and Kanban tools, improvement percentages were developed and analyzed for each of the indicators mentioned. There is a reduction of 0.07 hours in the lead time and a reduction of 0.19 hours in the cycle time (Figure 7).

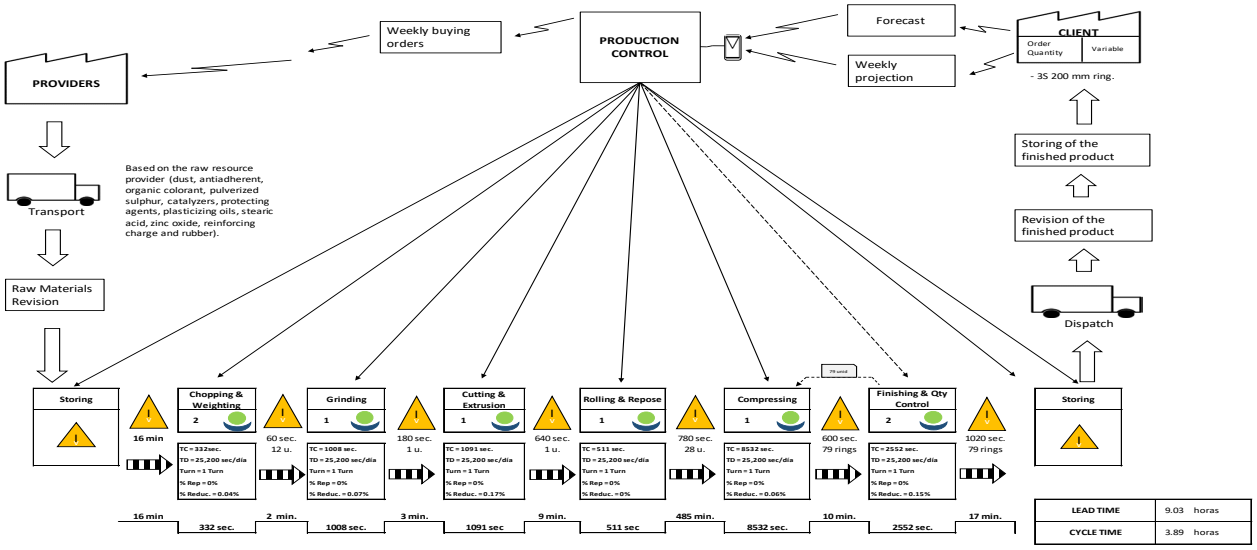


Figure 7. Proposed VSM of 3S 200 mm ring manufacture

5.3 Proposed Improvements

Seiri Implementation - Classify- For the implementation of the first S - Seiri (Classify) it was necessary to design a register, which allowed the identification of those products, tools, materials, instruments, among others, that add and do not add value in the area under study.

Seiton Implementation – Order- For the implementation of Seiton - Order, red cards had to be previously applied and the materials that add value in the process and work stations of the finishing area had to be separated.
Seiso Implementation – Cleaning- For the implementation of cleaning, which consists of the elimination of dirt in the work stations, processes or others.

Seiketsu Implementation – Standardization- For the implementation of the standardization stage, which consists of creating habits in the work environment, three criteria were defined and established in relation to the three main stages of the 5S tool to evaluate compliance with the established work methods. As a result of the Seiketsu - Standardization evaluation form, an average value of 83.33% was obtained between good (85%) and excellent (100%) for the three criteria (sorting, ordering and cleanliness) evaluated.

Shistsuke Implementation – Discipline- For the implementation of the discipline stage, it was necessary to address all the stages of the 5S tool (classify, sort, clean, standardize and discipline) and to define the criteria to be evaluated for each of them. Following the implementation of the 5S tool evaluation form, a total score of 104 points was obtained for all criteria and an average score of 86.95% for the finishing area in relation to the level of compliance with the tool.

For the development of a comparative table of the situation before and after implementation, it was necessary to use the results obtained from the evaluation sheet of the tool before and after implementation. To subsequently define through a descriptive table the data obtained for each of the stages of the 5S tool, which is as follows (see Table 5):

Table 5. Relation of the results obtained from the stages of the 5S Tool

STAGES OF THE 5S	LEVEL OFCOMPLIANCE	
	Before the implementation	After the implementation
CLASSIFY	28.57%	82.14%
ORDER	7.14%	89.29%
CLEAN	45.00%	90.00%

STANDARDIZE	16.67%	83.33%
DISCIPLINE	30.00%	90.00%
TOTAL AVERAGE	**25.48%**	**86.95%**

It can be said that after the presentation of the results for both situations (before and after) an average value of 25.48% was obtained before the implementation of the 5S tool, which after the implementation of the tool obtained a growth of 86.95%.

5.4 Validation

Statistical test in Minitab

Descriptive Statistics

Sample	N	Median	Std. Dev.	Median Std. Dev.
Productivity	6	56.466	0.557	0.23
Productivity2	6	75.856	0.920	0.38

Difference Estimation

Difference	Difference 95% Sup. Limit
-19.390	-18.573

Test

Null Hypothesis	$H_0: \mu_1 - \mu_2 = 13$
Alt. Hypothesis	$H_1: \mu_1 - \mu_2 < 13$

T Value	GL	P Value
-73.74	8	0.000

Figure 8. Normal Distribution

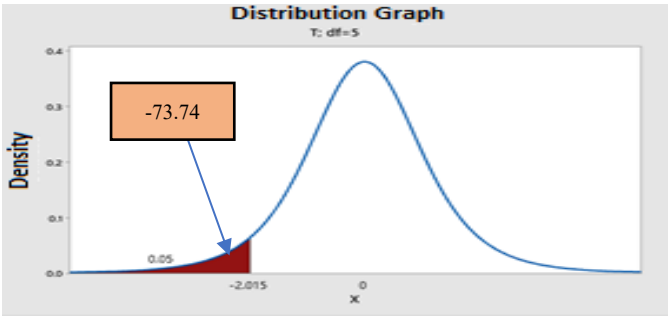


Figure 9. Normal Distribution

According to Figure 8 and Figure 9 we can reject the null hypothesis because it evidences that the productivity increases in a significant way.

6. Conclusion

Responding to the main objective of the research, it can be affirmed that after the correct implementation of the 5S and Kanban tool, productivity was improved because average results were obtained in relation to productivity where before the implementation was 56.47% and after the implementation a value of 75.16% was obtained; so there is a % improvement of 33.09% in the finishing area of a rubber company.

Improvement actions within the finishing area included a culture of order and cleanliness through the 5S tool (classify, order, clean, standardize and discipline) and a greater control of production through the Kanban method, which allowed to increase the efficiency of man-hours (m-h) based on what was planned, where before the application of Lean tools, an average value of 75.30% was obtained and a value of 87.03% was obtained. In addition, an improvement percentage of 15.58% was achieved, which indicates an optimal use of the resources of the production personnel in the finishing area of the rubber company.

In the same way, for the efficacy dimension, which is related to the units or quantities produced over the quantities programmed in the six-month period, an average value of 74.99% was obtained for the dimension before the implementation and 86.35% after the implementation. Likewise, an improvement percentage of 15.15% was achieved, which represents an improvement in the total production of 3S 200 mm rings in the finishing area of the rubber company. It is recommended that this study on the use of Lean Manufacturing tools be replicated in companies in the same sector in order to increase productivity in their different areas.

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