

Application of Lean Manufacturing and SLP tools to increase productivity in an SME in the textile sector

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Abstract

The textile industry in the last decade has considerably increased its competitiveness worldwide, being one of the most influential in the Peruvian economy. For this reason, it is necessary for textile workshops to maintain high productivity, and to be more efficient, making the most of resources in their production. Therefore, the objective of this research is to improve productivity and have better results with little investment, since the textile sector mainly has micro and small companies (SMEs) that occupy a large part of the market, as the company in the present case study. To do this, through the tools of Kanban, 5S and Systematic Layout Planning (SLP), they were implemented in the company to achieve the established objective. Thus, when implementing the 5S, it was possible to obtain better results in terms of a more orderly and clean work area, which allows workers to be more productive and have a better work environment. In the case of SLP, the relational diagram method was carried out and a simulation was carried out using the ARENA software, which had an increase in productivity by reducing the time to carry out a work order of 1400 T-shirts.

Keywords

Lean Manufacturing, 5S, Systematic Design Planning, Kanban, Efficiency and Textile Sector.

1.Introduction

From the financial perspective of the textile sector worldwide, a complicated situation is expected due to competition from countries with low wages, which causes a change in the structure of the supply chain of textile companies. In this sense, new structures such as outsourcing or mislocation can be observed. (Manfredsson 2016). This research will be focused on this sector, in which, worldwide, the number 1 country where 23% of textile production is concentrated is China; and in position 24, we can find Peru. Likewise, it may seem at first a place of not very high relevance worldwide; However, if the context of Peru is analyzed exclusively, it can be found that the textile sector from 2016 to 2020 had the contribution of 2.1% of employment and 0. 8% of the Gross Domestic Product (GDP), and within the manufacturing sector, to which it belongs, represented 6.3%. (PRODUCE 2021)

On the other hand, a factor that impacts the textile industry is the percentage of shrinkage that it has, which means those "losses" that are obtained throughout the process of the distribution chain and sales in the retail market. (Bruzzi sf). The processes where they are generated are in the transportation, storage, distribution, production, and sale of these goods that affect their nature and convert them into a quantitative loss, therefore, these losses can be counted, measured, weighed, etc., in units. (Ayala 2009). In the Peruvian textile sector, there was a drop in the production of the clothing subsector with a total of 35.9% between January and December 2020, where the most affected items were polo shirts, pants, and shirts. Likewise, a productivity of around 70 has been identified. 76% in a textile company

analyzed in a case study. (Elías and Vásquez 2022, p. 4). Regarding the total productivity indices of the clothing subsector, it is known that Peru is 1.21 according to figures provided by PRODUCE (2018).

This problem has been the subject of study in the textile sector since it is affected by productivity and quality problems. This is because, in production processes, entrepreneurs currently focus more on billing than instead of designing strategies that help achieve the most effective processes. (Larios 2017). For this reason, tools such as 5s and Six Sigma have proven to be effective in reducing costs and increasing the quality of products. (Really Vazquez-Vargas A. 2018). Likewise, according to the study carried out by Alanya B. et al. (2020), through the standardization tool, it was possible to reduce default reprocesses from 13.12% to 4.23% and delayed processes from 18.49% to 9.61%, which caused an increase in productivity. of 0.78 in the cutting area where the techniques were applied.

In this context, it is necessary for textile workshops to maintain high productivity, and be more efficient, making the most of resources in their production to generate more income with the same costs. Therefore, this case study reflects the problems of the sector related to the sector's productivity index with the company's index, which is lower due to various factors. Therefore, this index results in an economic impact where income is lower than it could be with the sector index.

In this sense, to solve it, several studies were carried out to find the appropriate tools, where it was decided to apply the Lean Manufacturing model by implementing the 5S, Standardization and SLP methodologies. These tools found in the analysis of the literature carried out were applied in situations with similar problems, achieving significant results, and which improved the situation of the company in various aspects. Therefore, these will serve to improve the problem not only in the company, but also as a contribution to the scientific community to help all Peruvian textile companies. The objective is to achieve great results with little investment, since the sector mainly has micro and small companies (SME) that occupy a large part of the market, as is the case study.

1.1 Objectives

1.1.1 General Objective

Increase the productivity of a company in the textile sector in Peru.

1.1.2 Specific Objective

Understand the deficiencies in current processes and develop Lean Manufacturing tools as a solution in the textile sector.

2. Literature Review

To obtain a broad vision of the textile sector and everything that it encompasses, an investigation was carried out in reference to the key concepts, such as the applications of the proposed solution tools to each problem diagnosed in this case study. In this review, a list of past studies will be made for each concept to obtain a solid base and, on the other hand, to find aspects that were not previously considered; and that, from this research, value can be created for the scientific community.

2.1 Lean Manufacturing

Currently, textile companies present various operational problems where productivity is affected. The main problem that is currently found is that manufacturers seek to offer high quality products or services in the shortest possible time and generate low costs. (Venkata et al. 2017) Therefore, there are different mechanisms to improve the situation of this problem, such as the implementation of lean, which one of its objectives is to improve production management, as well as achieve high levels of productivity. (Cuellar-Valer et al. 2021; Sosa-Pérez et al. 2020).

Finally, as benefits of Lean, an increase in sales is highlighted by adapting production to demand, a reduction in delivery time, elimination of waste, cost reduction, increased efficiency in managing resources and effectiveness that leads to greater productivity, more employees. committed and trained, improved communication, a quality product, satisfied customers and, in general, sustainability for the company (Durand-Sotelo et al. 2020; Mohan et al. 2019; Xuejie et al. 2019).

Therefore, the implementation of the Lean philosophy in the manufacturing sector is evidenced in an improvement in cost performance, where the elimination of waste increases the optimization of resources and productivity in a high percentage. (Dos Santos et al. 2020). Likewise, in another study it was observed that this implementation of Lean helps companies that are in search of continuous improvements, where after applying it, it achieved a reduction of 300

seconds after applying a standardization process and in turn a decrease of 5%. of defective products, and the 5S methodology could also be applied after staff training for its implementation. (Barrientes 2020)

2.2 Kanban application

Kanban is a methodology that focuses on a signaling system that helps to plan orders and to schedule daily tasks in a more orderly manner and the function that the progress of operators and activity can be monitored on the calendar. has as a priority. This is thanks to the fact that letters can be used that detail pending activities and have relevant information that the operator should know. (Mohan, 2020) (Aldas et al. 2018). In case studies such as Sosa's (2020), it could be seen that applying these tools in a textile factory generated a good impact, thus increasing efficiency from 55.88% to 76.79%. This made it possible to increase the efficiency and effectiveness ratios that helped to increase the level of the company. Taking this into account,

2.3 Application of 5s

Manufacturing companies have recurring problems related to productivity, caused by the low efficiency of resources. That is why the 5s application is one of the best tools to improve productivity, quality, safety, and work environment, in short periods of time and with low implementation costs. Likewise, it is a tool applied to reduce the high times of mobilizing in the workspace and searching for materials or tools.

In this sense, the implementation of the 5s tool managed to obtain positive results such as the improvement of the use of the work area, which had identified losses of time and even resources due to poor organization and cleaning. Efficiency and productivity were benefited. Another of the findings in the case studies was the positive impact of the application of 5s in other tools such as Just in Time or TPM. A significant aspect that was achieved through the tool was the formation of a considerably productive work environment, since motivation increased, communication between supervisors and operators improved, discipline too. In addition, accidents and occupational hazards decreased.

2.4 Application of SLP

The SLP tool is often used to organize a workplace in a plant so that faster material flow can be achieved with less amount of handling. The SLP model is basically based on features like construction cost, connectivity cost, and modernization to make the material flow system as simple as possible. Likewise, the method encompasses qualitative and quantitative factors. For this, SLP consists of 3 important steps: Analysis, investigation, and selection. This method manages to increase the efficiency of the workforce through the comfort, safety, and ventilation of the work area, and even more importantly, it facilitates the supervision and control of the tasks to be carried out in the workplace.

It has been possible to observe how the SLP method generates benefits by increasing productivity, decreasing production time and the total distance traveled by material. Likewise, SLP achieved results such as better use of machines, reduction in the probability of accidents, and greater job satisfaction.

3. Methods

To carry out this production model, a paper guide was taken into consideration, which analyzed the models proposed by different authors. These articles provided a clearer idea of how to implement different methodologies such as Lean Manufacturing to improve productivity in the textile sector. These articles propose different models that will guide the solutions of problems related to the company in question. Therefore, an improvement in productivity can be achieved with these by implementing the procedures that these articles successfully applied and providing a clearer path of the steps to follow to achieve the success of the proposals.

Table 1. Comparative table of the Components of the Proposal vs. State of the Art

Author	Non-standardized cutting process	Poor workflow control	Poor quality control	Lack of cleanliness in work area	Undefined inventory area
Kaneku et al (2019)	5s	5s	5s	5s	-
Bracamonte et al. (2019)	5s	kanban	5s	5s	-
Flores-Meza et al. (2020)	-	kanban	5s	-	-

Asad et al. (2016)	-	-	-	-	SLP
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3.1 Proposed Model

For this proposal it will be divided into 3 main components. The first will be the analysis of the initial situation, where it is possible to obtain data from reports that will help in the identification of the company's problems. The second will be the implementation of the methodology where the Lean Manufacturing tools mentioned above will be applied, which will help improve productivity. Finally, the third component will be the evaluation of the final situation, where it is verified and tested that the proposed methods were implemented correctly, which in turn achieved good benefits.

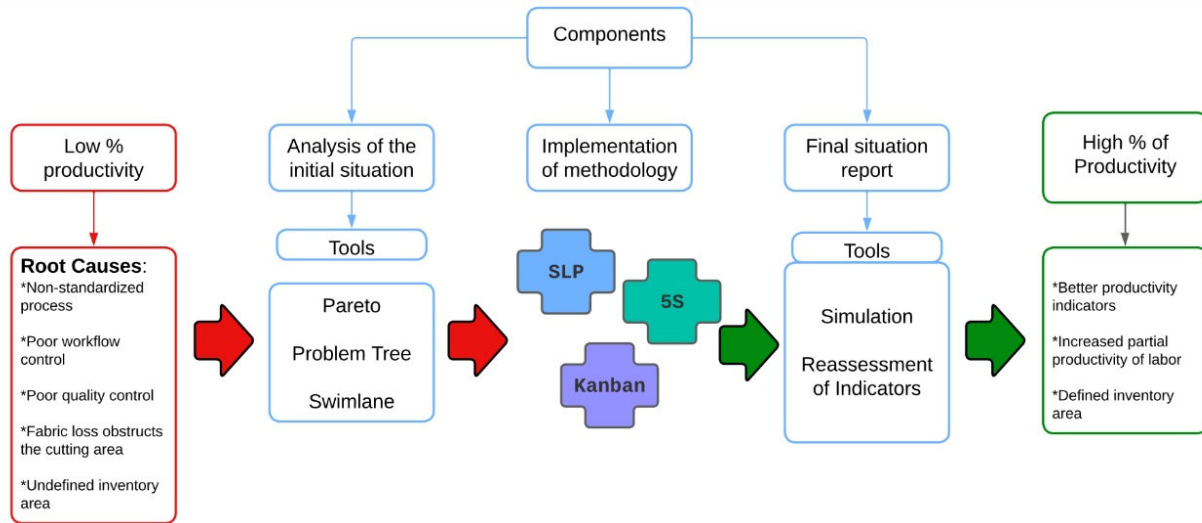


Figure 1. Production model

3.1.1 Analysis of the initial situation

In this first stage of the proposed model, the objective is to search and analyze the current problems of the company. For this, an in-depth investigation was carried out on the main problems that the sector currently faces and quantitative information was obtained, which was compared with the information provided by the company. In this way the technical gap was achieved.

Continuing with this stage, different tools such as the rail diagram were used to find the causes of this technical gap, and with the support of the Pareto diagram, the investigation was directed to attack the problem that represents 80% of the economic losses of the company. Finally, the ideal tool to obtain the most appropriate methodologies was the problem tree, with which it was possible to obtain the root causes and propose solutions by formulating objectives.

3.1.2 Implementation

The second phase of the investigation consists of the implementation and application of the engineering tools proposed in the problem tree. These tools are: Kanban, 5s and SLP. For this, we begin by detailing the procedure to be carried out for the correct application of 5s, a Lean tool that will seek to solve the problem of order and cleanliness in the work area. In this first evaluation there will be a total of 10 criteria to evaluate for each s and those that the company in question meets will be marked.

Likewise, it is important to write down those observations and suggestions that are needed for the implementation stage. If the Score is less than 8, it will be classified as an improvement requirement. During the implementation of standardization, it is essential to carry out training for operators in the logical order that they must follow and give constant feedback on errors that reduce productivity. Finally, the proposed process will be shared with each member who is part of the workshop in order to control the results obtained. At the end of the evaluation, a record of images will be made that can validate the application of the tool. Those criteria that have not been marked will be analyzed and improved in order to reach the minimum acceptable score.

On the other hand, in order to carry out the redesign of the workshop that optimizes the time and route of the operators to the materials, eliminate the risks and the obstruction in the work space of the operators in the cutting station; the SLP tool will be implemented.

In turn, this tool will be applied together with the Kanban tool, which with this tool, will bring benefits by helping in the organization of the workers' work plan, thus having a better workflow where for this, what will have to be done will have to be done. following: Data analysis of order orders, production scheduling, developing cards where you can observe the steps to carry out the different types of model according to the garment, making a diagram where you are in which purchase order processes are operators are located and what purchase order they are working on.

3.1.3 Evaluation of Results

In this final stage, the objective is to monitor the tools applied to the identified problems. To do this, in the case of Lean tools such as 5s and Kanban; monitoring through KPIs is essential, which allow us to identify whether there is a trend towards continuous improvement or not. The follow-up process must be weekly until it is guaranteed that the training of the employees has been completed, subsequently, the discipline proposed by the 5s method must continue to be insisted on, otherwise it is likely that even the results obtained in the process will be lost. The SLP method will be carried out through simulation and monitoring will be carried out with indicators such as the total distance traveled or time to obtain the tools or materials.

3.1.4 Process diagram

In this way, a map was made detailing the step by step of the proposed model. This can be seen in Figure 2.



Figure 2. Diagram of the model

4.Data Collection

For the investigation, a general evaluation of the cutting area of the textile company has been carried out, where the main textile activities are carried out, since the printing and clothing process is outsourced. In this, it has been possible to identify and document a series of problems or shortcomings that are affecting total productivity.

The company in question, currently works through work orders where the details of the task to be carried out are specified; however, its current working method has certain deficiencies in relation to the times and priorities of each order; which can end up generating deliveries out of time or an increase in internal lead time, so that the image of the company is harmed. For this, the Kanban tool is ideal as a solution method and added to 5s, it will allow a correct workflow. As the main base of Kanban, the Kanban board is introduced to the process, which has 3 different statuses; Back log, To do, In process and Done.

In addition to the Kanban board, the Kanban card is included, which will be present throughout the cutting area process. This contains the person responsible for the task, fabric, fabric color, product, code, start date, due date and observations.

Regarding the next tool, the 5s qualification criteria, it has been determined that the company has a qualification of 23 in this first verification and taking into account that 50 is the maximum total score, so there is a great margin for improvement. For this reason, through the implementation of 5s, the opportunities for improvement will be defined for each "S" and proposals will be made for each of them.

Table 2. Initial audit 5S

5S		starting score
S1 (Series)	Select	4
S2 (Seiton)	Order	4
S3 (Six)	Cleaning	4
S4 (Seiketsu)	Standardization	7
S5 (Shitsuke)	Discipline	4
Total		23

On the other hand, the Systematic Layout Planning tool will be used, which is essential to reduce costs and improve productivity. To carry it out, the measurements and distribution were taken into account in order to organize it, in such a way that a better workflow in the company is guaranteed to make it more efficient. Therefore, the corresponding steps will be taken to obtain the improvement in distribution. Where, later with the Arena program it will be possible to simulate and thus demonstrate how efficient it is to apply it.

Table 3. Table of process activities

Zone A	Zone B	Time travel	Route (Meters)
Administration area	Cut Zone	15.477 seconds	24.0
Cut Zone	Fabric Warehouse	3 to 5 minute	16.04
Fabric Warehouse	Cutting table	3 to 5 minute	16.04
Cutting table	P.T. Warehouse	4 minute	11.22
P.T. Warehouse	Dispatch of Orders	3 minute	9.95

Finally, the summary of the KPIs analyzed in this initial stage can be seen in Table 4.

Table 4. Initial phase KPIs

Indicators	Initial state
Productivity	3.8 T-shirt/min
Meters traveled	61.17
Transfer times	9.87
5s score	23

5. Results and Discussion

5.1 Numerical Results

After the implementation of the 5S, once the improvement proposals were applied, the significant improvement could be observed with the implementation of this tool. This audit was done in order to evaluate the process and verify if the measures were being met. Therefore, it was possible to verify that the improvements were actually made and thus having a higher score in the 5s audit.

Table 5. Final score of 5S audits

5S		Initial Score	Current Score
S1 (Series)	Select	4	8
S2 (Seiton)	Order	4	8
S3 (Six)	Cleaning	4	8
S4 (Seiketsu)	Standardization	7	6
S5 (Shitsuke)	Discipline	4	6
Total		23 (46%)	36 (72%)

With this new score, it was possible to improve the work environment, which allowed the operators to carry out their work in a more orderly, clean, and organized manner, thus becoming more efficient in carrying out their activities.

Regarding the application of SLP, with the proposed plan and using for this scenario a work order from the company of 1400 T-shirts, a simulation was carried out using the ARENA software of the initial situation and the final situation. Finally, as can be seen below, the results were slightly positive with 95% confidence. Transport times were reduced

Table 6. Comparison of indicators

Indicators	Current situation	improvement model
Transfer time to cutting table	3	0.5
Transfer time to finished products	4	2.4
Transfer time to Dispatch	2.8737	0.45
total cycle time	360.60	353.30

With the reduction of the cycle time, in the proposed scenario of the work order of 1400 T-shirts, it has been possible to reduce the time spent in carrying out the task by cutting the transfer meters. Finally, the following proposed improvements are exposed.

Table 7. Comparison of KPIs

	as is	To be	Results
Productivity	3.8 T-shirts/min		4 T-shirts/min
meters traveled	61.17	-	17.4
transfer times	9.87	-	3.35
5s score	23	40	36

5.2 Graphical Results

Once the relational diagram method was carried out in the SLP tool, the proposed plan was obtained, which can be seen in section 5.4 of validation. With this plan and the new meters of travel with their respective transfer times, the simulation was carried out in the ARENA Software of the cutting process of a work order of 1400 shirt collar polo shirts. This order specifies the sizes for both male and female cut for the main client. To run the model, a replication length of 3 days and 8 hours per day was taken into account.

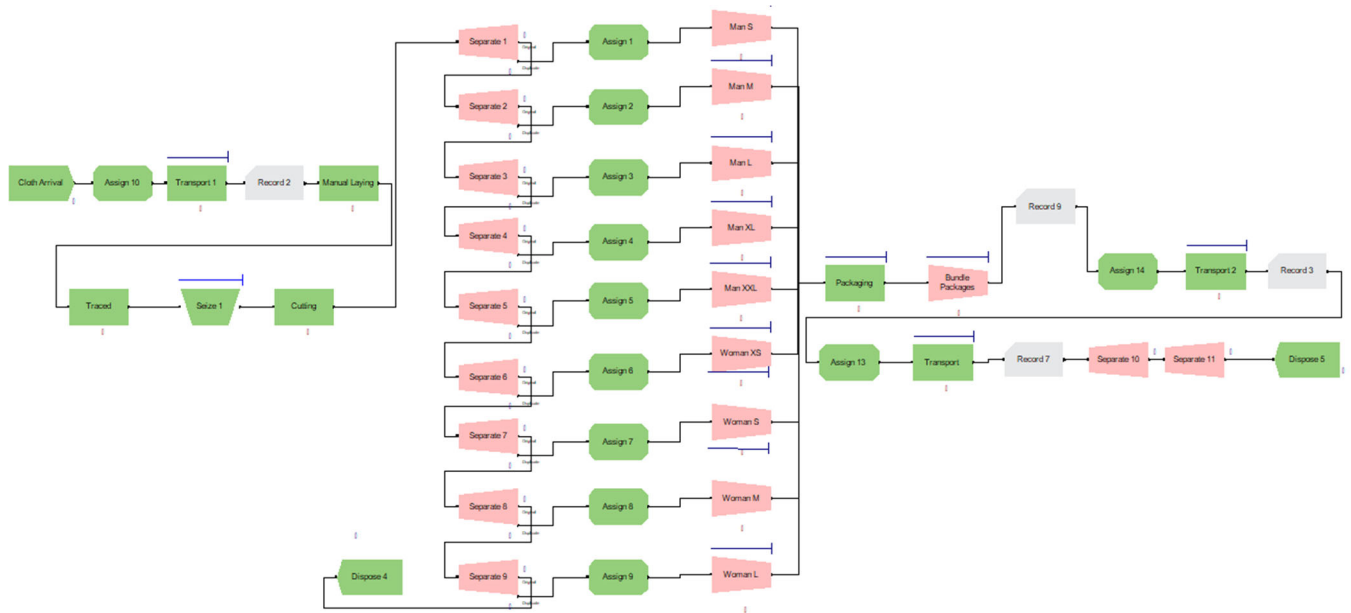


Figure 3. Simulation of the model in Arena

5.3 Validation

For the SLP method, it was proposed to reduce the distances that exist between the cutting area and the fabric and finished products warehouse so that the cutting operator does not waste time in transferring inputs and outputs; Likewise, the space between the finished products warehouse and the dispatch area was reduced, since, since the printing and clothing processes are outsourced, this journey is made daily by those in charge of sending the fabrics. With these modifications previously proposed by the relational diagram method, productivity increased by reducing the time to carry out a work order.

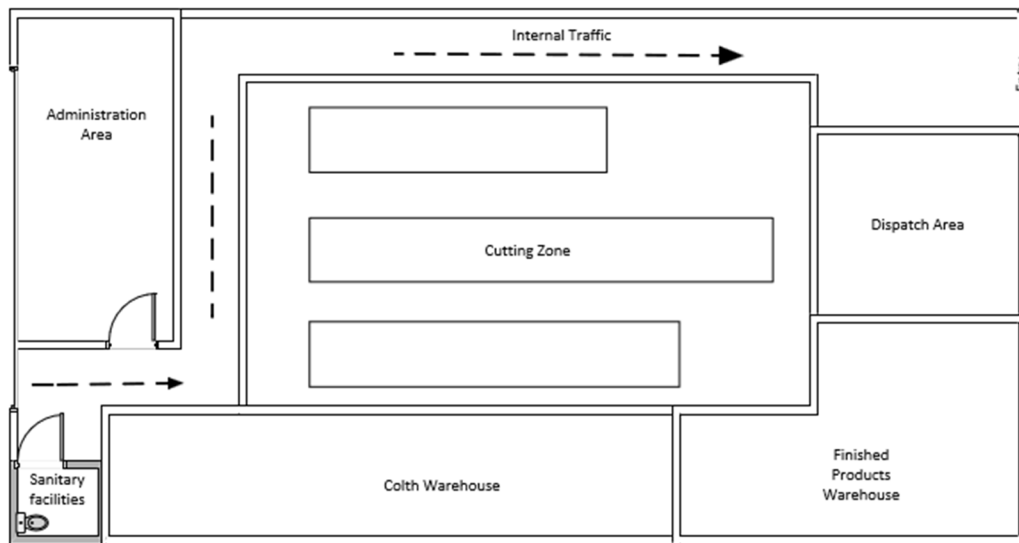


Figure 4. Proposed plan

For the validation of the 5S tool, audits were carried out where compliance and monitoring of its application was verified, which had the objective of compiling the results obtained, and knowing in which discipline it has to be improved. Under this context, once the audit results are collected, corrective actions will be presented, which begins with the identification of non-compliant disciplines, determining their causes, implementing the proposed solution,

performing a re-audit to verify compliance with the proposals and finally collect these new data obtained. As a result of the last audit that was applied, figure 3 shows the 5S radar graph, which presents a good indicator with respect to the one obtained at the beginning. Thus,

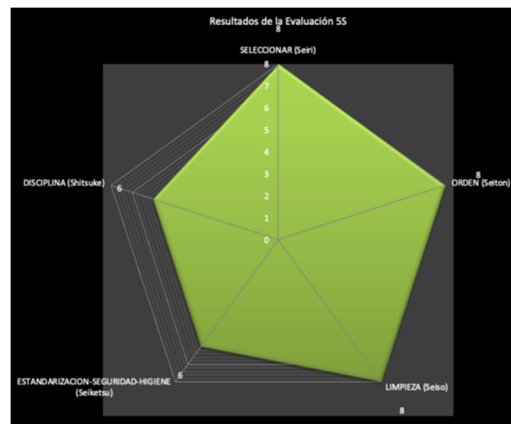


Figure 5. Results of the 5s Assessment

6. Conclusion

It is concluded that the implementation of the 5S, Kanban and SLP tools have shown to increase the productivity of the ca. These tools allowed reducing the time in the manufacturing process, improving order and cleanliness, and improving the process flow, which helped to solve the root causes of the previously mentioned problem tree, when the initial situation of the company was analyzed.

In turn, it can be concluded that for the applied tools to be successful, a commitment must be required from all the people involved, as well as feedback, which is essential, since it allows the effectiveness of the tool to be achieved, achieving continuous improvement. sustainable and not temporary. Thus, it was possible to achieve the proposed objectives and the correct development of the investigation.

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