Proposed Improvement Plan with Lean Manufacturing to Increase Productivity in a SME in the Textile Sector in Peru

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Abstract

In Peru, the textile industry is the third activity with the highest contribution to manufacturing GDP. However, most companies suffer from a lack of production planning, organizational culture, and training. This research has focused on the development of an improvement model proposal, combining Lean Manufacturing and Systematic Layout Planning tools to solve the main problems that arise in this type of company. Which is evaluated through a simulation in the Software Arena for its validation, where a decrease of 39.76% of the transfer time was obtained, a reduction of the cycle time by 15.11% and an increase of 17.99% of productivity.

Keywords
Lean Manufacturing, Systematic Layout Planning, Textile Industrial, Productivity Improvement, SME.

1. Introduction

Globally, the textile sector represents a significant part of the world's gross domestic product (GDP). In 2017, the indicator for the textile sector worldwide was 3.4% (Flores-Meza et al. 2020). Between 2016 and 2019, out of every 10 garments sold, less than one unit was acquired from the national producer in the I Semester 2020 (Institute of Economic and Social Studies 2021). The study clearly shows that the entrepreneur has to understand that one of the most important challenges he faces is to remain competitive in the market (Vargas-Hernández et al. 2018). Since this has a strong impact on the economic growth of a country, as is the case of Peru. For this South American country, the textile industry is the third activity with the highest contribution to manufacturing GDP (6.4% share in 2019). However, according to statistical studies by the Central Reserve Bank of Peru (2021) they revealed that the textile sector only reached 51.17% of its capacity on average for the year 2020.

This mostly affected small and medium-sized companies, where the lack of productive planning, organizational culture and training compromised service levels. In addition, several studies indicate that this problem is due to unproductive times and defects (Durand-Sotelo et al. 2020). These problems mainly generate excessive movement and transport, a low level of productivity and delays in orders (Ruiz et al. 2019). These problems have also been identified in other investigations in different countries. For example, in a textile company in Colombia, a percentage of unproductive times of 40% was identified, due to the lack of standardized procedures for operations prior to the assembly of each production order, which represents non-compliance with schedules, delays in the deliveries of the order orders and low productivity in the plant (Martínez Sánchez et al. 2014). Another investigation in a textile company in Peru, the company had a high cycle time of 33.64 due to waste from the processes. This prevented it from meeting the demand for the product, meeting only 34% of the total (Ruiz et al. 2019). The studies mentioned above show that companies in the textile sector present inefficient processes, which is why it is important to continue investigating new solutions to this problem.

For this, a case study was chosen that reflects the main problems facing the sector. The wastes identified are unnecessary tours, reprocesses due to defects and unproductive times, which generate monetary losses equivalent to around 4% of the net profit of the case under study. In this sense, a proposal for an improvement model was developed combining Lean Manufacturing and Plant Design tools. This model was developed based on the different success stories, in companies with similar problems, found in the reviewed literature and that satisfies the need to solve the problems of the sector as its contribution to the scientific community. This research offers a new improvement model combining Lean Manufacturing and Plant Design tools. It should be noted that there is a large amount of research in textile companies in which Lean Manufacturing is applied.

The scientific articles reviewed contain little information on Lean Manufacturing models along with Plant Design for this type of company, especially in Latin America. Due to this reason, the need to carry out the present investigation arises.

1.1 Objectives

There have been relatively few studies that propose a model to improve productivity in SMEs in the textile sector. Therefore, this research has two main objectives. The first objective is to identify the root causes of the main problems faced by this type of company. Based on the results found, the second objective is to develop and propose an improvement model that can solve the identified problems.

2. Literature Review

2.1 Lean Manufacturing

According to Gallardo and Rau (2020), the Toyota Production System, normally known as Lean Manufacturing, has as its main definition “doing more with less” referring to the use of fewer resources such as time, space, machinery, raw materials and labor, while meeting customer requirements. In addition, within the lean methodology, the participation of the tools is determined: value stream map (VSM), Kanban, TPM, 5S, among other tools. Likewise, these tools allow finding hidden problems, as well as defining activities that do not add value to the product and the creation of indicators and goals to achieve continuous improvement (Sarria Yépez et al. 2017) (Vargas-Hernández et al.2018). That said, the lean methodology is a combination of techniques which aims to improve the productivity of SMEs by eliminating waste (Cespedes-Pino et al. 2020). According to the analysis carried out on the literatures, it has been shown how this methodology has evolved since its inception and is currently used in manufacturing, services, research, and development. This is also used in both public and private sectors (Gazoli de Oliveira and da Rocha Junior 2019).

2.2 Systematic Layout Planning (SLP)

Systematic Layout Planning, or SLP, is used as a tool to design a new plant layout that is optimal for the business process. With the use of SLP and Lean tools, efficiency in the material flow is achieved (Ruiz et al. 2019). Likewise, SLP is a technique that requires step-by-step planning of procedures that allows users to identify, visualize and qualify the various activities, relationships and alternatives involved in a design project (Jain and Yadav 2017). Implement the technique under study serves to reduce the efforts made in the operators of the production process reducing material handling Quispe et al. (2020). According to Lista et al. (2021), the SLP model allowed the resolution of the plant distribution problem through the development of a sustainable layout proposal, which have provided several gains in social, economic and cultural terms. The new layout improves the quality of work by reducing unnecessary movement and long routes. In economic terms, the proposed layout allows efficient service provision.

2.3 5S methodology

According to Piñero et al. (2018), the name of the 5S methodology comes from the Japanese terms for the five basic elements of the system: Seiri (selection), Seiton (systematization), Seiso (cleanliness), Seiketsu (normalization) and Shitsuke (self-discipline) (p. 5). This methodology has great relevance in the creation of a clean, organized and safe business culture with the aim of giving a panoramic vision of the company to improve its productivity (Kaneku-Orbegozo et al. 2019). This tool helps reduce workflow problems, increase product quality and productivity, and improve communication. Likewise, it improves safety in the workplace by eliminating hazards and establishing compliance with labor standards (C 2018).

Each of the 5 elements has a corresponding meaning of which Flores. et al. (2018) tells us: Seiri (Select): Its final objective is to free the spaces of the pieces, documents, furniture, broken tools, waste, among other items, that are not required to carry out the work and that only obstruct its flow. Seiton (Order): At this stage, a specific place will have to be ordered and organized for each thing and everything in its place in such a way as to minimize the waste of movement of employees and materials. Seiso (Clean): Consists of cleaning and inspecting the work site and equipment to prevent dirt, implementing actions to avoid or reduce dirt and make work environments safer, it also involves determining the causes, to solve the root problem, avoiding repeating the same situation. Seiketsu (Standardize): In this phase you can use the location of photographs of the work site in optimal conditions so that workers can see the state in which it should remain. You can also use the development of clear and specific cleaning standards, in addition, you can make a visible procedure for everyone that clearly explains what the guidelines are to keep the area in order and clean. Shitsuke (Discipline): the procedures already established in the organization must be prevented from breaking in order for cleaning to be part of the company culture. Only if self-discipline is implemented and compliance with the rules and procedures adopted will it be possible to enjoy the benefits they provide.

2.4 Standardized work

Standardized work is a document that captures manufacturing procedures to identify best practices. It has to be a live document with ease to change (Muthukumaran et al. 2019). One of the characteristics of standardized work is to maintain the rhythm of production linked to market demand through the concept of takt-time (Fazinga et al. 2019). Likewise, Abbe and O'Keeffe (2021) indicate that the standard work consists of a set of standard parameters that is used to verify if the processes were successful. This method became a best practice for continuous process improvement. According to (Martínez Sánchez et al. 2014) standardized work is a primary factor for all organizations, since through this it is possible to obtain products with a homogeneous quality due to the fact that similar working conditions are maintained, which include materials, equipment, machinery, procedures, methods, skills and knowledge of the personnel during the execution of operations.

2.5 Productivity improvement in the textile sector

In different articles it is confirmed that Lean Manufacturing is a work methodology whose application generates an increase in productivity through reduction of waiting times, elimination of unnecessary movements, reduction of defective products (Dextre-Del-Castillo et al. 2020; Ruiz et al. 2019). Likewise, other studies show that this methodology develops solutions regarding both administrative and production management and quality improvement (Flores-Meza et al. 2020; Sosa-Perez et al. 2020). In addition, Gazoli and da Rocha (2019) indicate that the critical analyzes of the operational problems faced by companies after applying the Lean Manufacturing method verified the increase in productivity and its representation with respect to the decrease in production costs. Finally, in the empirical studies Durand-Sotelo et al. (2020) and Gallardo and Rau (2020) managed to highlight the benefits of the implementation of the Lean Manufacturing methodology within SMEs of the textile sector, showing not only results of increased productivity, but also improvements in workplace safety and the model of production.

3. Methods

Currently, companies in the textile sector are forced to improve their processes in order to improve their competitiveness within the market. In this sense, the literature identifies those authors such as Rodrihez et al. (2014), Flores et al. (2018) and Kaneku-Orbegozo (2019) use Lean Manufacturing tools such as 5S and Standardized Work to solve reprocessing problems. While, on the other hand, some authors such as Ruiz et al. (2019), prefer to use the SLP to solve the problems of plant distribution and transfer overtime.

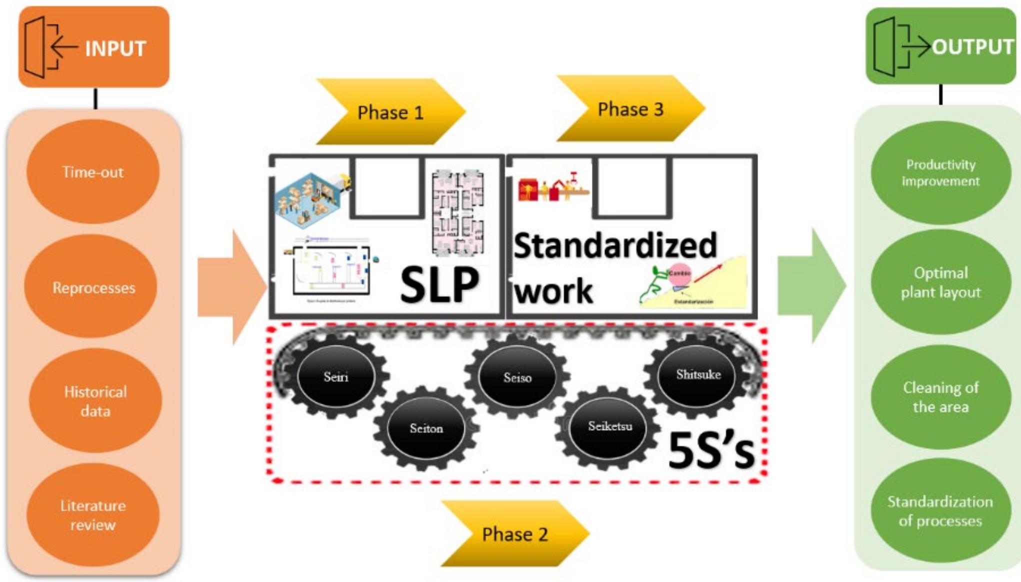

Figure 1. Main figure of the contribution

3.1 Improvement Proposal

Our contribution is to propose a model to increase productivity by combining the SLP and the 5S tools and standardized work to achieve a solution to the main problems that companies in the textile sector present. As shown in Figure 1, It is proposed to use the 5S tool to improve poor organization and disorder in production areas. To achieve a better plant distribution, the SLP method is proposed. Finally, to reduce the amount of reprocessing in the area, it is proposed to implement Standardized Jobs. Like any process, it is necessary to determine the inputs and outputs. The entries refer to the historical data of the company's processes and the analysis of its current situation. The outputs of the model are equivalent to the improvement of production processes and the new procedures and indicators proposed. For the development of the proposal, it will start with the SLP tool, since this will allow the optimization of the installation through the efficient distribution of the processes based on the process flow. The 5S tool allows to identify the objects, tools and activities that are not necessary in the work area and then define the standards of order and cleanliness of the area in order to have a correct operation of the operator. Finally, standardized work will be implemented which will allow the operator's functions to develop correctly under a detailed and specified process. This in order to reduce failures and errors that compromise production.

3.2 Detailed Contribution

Phase 0 is made up of all the activities prior to the implementation of the proposal. This consists of preparing all the data and work tools on the improvement project. To do this, it begins with obtaining the general and operating data of the company. Then, we proceed with the search for improvement tools for the current problem and the importance of solving it. The objective is to have all the problems of the processes involved to generate an optimal decision for improvement. Finally, the improvement proposal is prepared with the work plan for the development of the model.

The execution of the phase 1 will be comprised of the SLP tool that aims to obtain the best distribution of the workplace. This first step begins with the analysis of the current situation, which will help us to optimally carry out the distribution proposal for the work teams. Based on the intervention of each team in the process. Finally, the redistribution of areas will be carried out through the assigned proposal. This technique will benefit working times, ensuring the performance and efficiency of the production process. Likewise, we determined that the SLP would be the basis for the other techniques of the present investigation: 5S's and standardized work.

Phase 2 of the model consists of applying the 5S tool, which consists of maintaining order and cleanliness of the workplace through activities classified by each of its stages as shown in Figure 2.
For the classification it is required to inspect the place to determine the waste of the work area. This step will help identify waste and unnecessary materials in the area. Then, it will be required to order each element that intervenes in

the workspace and register it. Based on this, the cleaning activities that consist of keeping a clean and residue-free place are assigned. Finally, a cleaning policy will be implemented which allows the operator to avoid placing waste in the process area. To comply with this, a supervision will be carried out to verify compliance with the cleaning policy.

In the development of phase three, there is the implementation of the standardization of work which aims to reduce defective products in process generated by the incorrect execution of productive activities. This directly affects the productivity of the company. The implementation of this tool begins with an analysis of the most relevant operational failures in the clothing area and segmenting the work stages. Then, the critical and necessary processes to develop a standardization will be determined. Finally, the standardized activity will be implemented through training. The following figure presents the flow of activities step by step to apply the proposed combined improvement model.

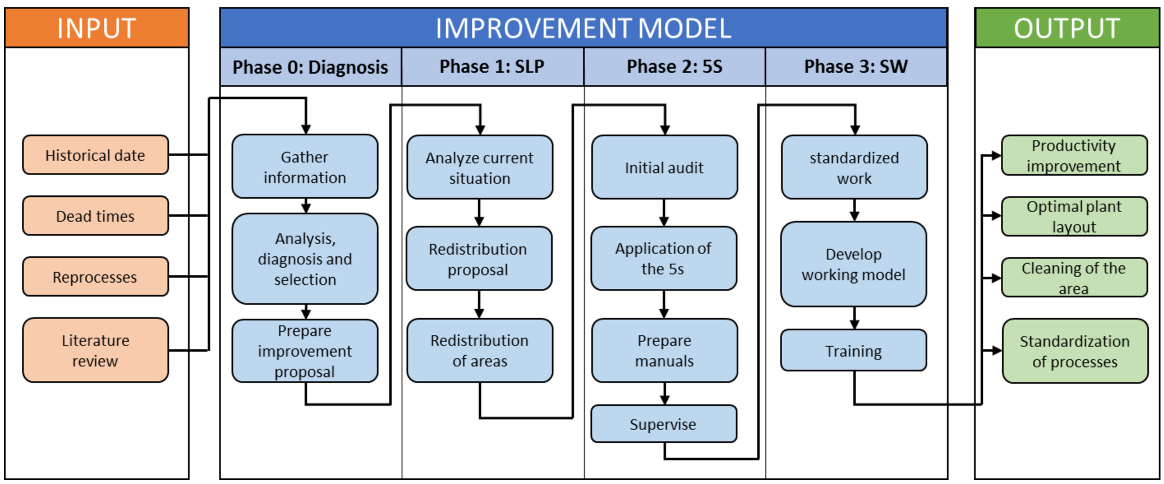

Figure 2. Proposed Contribution flow diagram

3.3 Indicators

In relation to unproductive times, we use as indicators the reprocessing times of defective products and the times of movements or transfers between jobs. On the other hand, the indicator of defective products, productivity and production cycle time will be used. Which will be analyzed before and after the implementation of the improvement proposal model.

Productivity: It allows calculating the quantity of products manufactured per man-hour used.

$$Productivity = \frac{1}{Cycle\ time} * 60$$

4. Data Collection

To obtain the results when applying the proposed methodology, our development was carried out in a small enterprise of the textile sector of the city of Lima-Peru, a study was carried out within the work environment. The research consisted of collecting data in a descriptive way, then applying the proposed tools and finally validating results through the use of simulation in the Arena software.

5. Results and Discussion

Analysis of results from the application of the proposed tools using the Arena software. For the development, two scenarios will be carried out, the first based on the simulation of the current situation of the company, whose data used was a compilation of times taken in each stage of the process during a week, as well as in its transport, the second stage It is after implementing the proposed improvement. For both scenarios, the data was placed in the Input analyzer Program, to find its distribution in each process, in both cases the result was the Beta distribution for each one, in this way it was simulated according to the model show in Figure 3 in the arena software to verify the results. Table 1 shows the times for each process and transport in Buzos (sports pants and jacket) production before and after the proposed improvement.

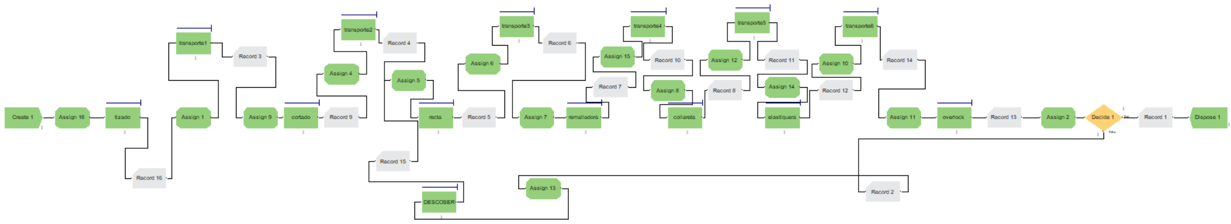

Figure 3. Simulation model diagram

After the improvement, it is evident that the time of the processes, as well as the transport times, were considerably reduced. The results show a 15.11% decrease in cycle time, which directly impacts productivity. Which, after the solution proposal is implemented, as shown in Table 2, increases by 17.99%. After implementation, a decrease in the number of defective products is observed by 58.62%, going from 1.93 to 0.8 defective units per day.

Table 1. Cycle time before and after

Process	Time Before (minutes)	Time After (minutes)
Chalked	4,115	3,785
Serger	2,465	2,087
Straight	7,417	6,322
Overlock	7,103	6,288
Elastic	6,130	5,404
Chopped up	7,727	6,091
Collareta	7,627	6,112
Transportation1	0.169	0.103
Transport2	0.168	0.101
Transportation3	0.165	0.099
Transport4	0.168	0.117
Transportation5	0.167	0.102
Transportation6	0.166	0.082
Total cycle time	43,225	36.69

According to the results obtained in the simulation in the Arena software, a 53.36% decrease in unproductive times due to reprocessing would be obtained. In addition, after the implementation of the new distribution with SLP, a decrease of 39.76% in the travel time for each manufacturing cycle is recorded.

The results obtained according to the simulation carried out in the Arena software contrasted with the time studies in the plant were as expected. Starting with the SLP where, due to the new plant design, a decrease in transfer times was obtained. In addition, due to the application of the 5S's and the standardized work, it was possible to reduce the number of defective products, the unproductive times due to reprocesses and this could be reflected in the decrease in the cycle time. In agreement with our model, Kaneku-Orbegozo et al.(2019) and Dextre-Del-Castillo et al. (2020) they managed to obtain a decrease in cycle time of 15.25% and 10.36% respectively. However, the model of Ruiz et al.(2019) obtained a decrease of 24.73% which was considered as a higher decrease, but this can be explained due to the total elimination of the queues that they took in their second simulation model, which greatly reduced the cycle time.

Table 2. Indicator

Indicator	Before		After		Variation
Cycle time	43.22	Minutes	36.69	Minutes	(-)15.11%
Productivity	1.39	U / HH	1.64	U / HH	(+)17.99%
Defective Products	1.93	Units/Day	0.80	Units/Day	(-)58.62%
Reprocesses	66.48	Minutes / Day	31.01	Minutes / Day	(-)53.36%
Travel times	1.00	Minutes / Cycle	0.60	Minutes / Cycle	(-)39.76%

6. Conclusion

As it could be observed in the results, the proposed model serves to solve the productivity problem on the elaboration of a diver in a textile MSE and is available to solve other similar cases in organizations with similar characteristics. In the analyzed company, 2 major causes that led to low productivity were detected: presence of unproductive times, and the number of defectives, the improvement proposal worked on managed to increase the productivity of the company by 17.99%. The application of the SLP methodology managed to reduce travel times by 39.76%, from 2.32% to 1.65% of cycle time. The application of standardized work achieved a decrease in defectives by 58.62%, from 16.11% to 6.67% with respect to the total quantity produced. Finally, this model allowed a 58.62% reduction in reprocessing time for defective products. For future research, it is recommended to focus on other processes or areas, such as supply chain management, looking for opportunities for improvement and achieving better benefits for the company.

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