Production Model Based on Lean and SLP to Increase the Level of Service in a Peruvian Textile SME

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Abstract

The textile sector is one of the most important sectors in Peru. Currently, the Peruvian market is highly competitive not only among domestic producers, but also with imports of textile products, which have been increasing progressively in recent years. Therefore, for a textile manufacturing company to be competitive in the Peruvian market, it must not only focus on offering the best price, but also a high level of service that allows it to differentiate itself from other competing companies. In this sense, the use of lean tools such as TPM and 5S integrated with SLP is proposed to improve the service level of a textile SME. To support the effectiveness of the model and the improvement of the critical indicators, the model is validated through a pilot test and simulation. As a result of the application of the model, an increase of 25% in OTIF, 13% in overall equipment efficiency, 11% in production and reduction of 34.57% in search time were obtained.

Keywords
5S Methodology, TPM, SLP, Service Level, Textile Sector.

1. Introduction

In Peru, the textile sector is one of the main industries that has a positive impact on economic development, contributing annually 6.4% of manufacturing GDP and generating around 400 000 direct jobs per year (Sociedad Nacional de Industrias 2021). In addition, 35 798 companies are registered, of which 99.5% are SMEs with a creation rate of 5.4% and an exit rate of 2.2% per year (Produce 2021). Within the textile sector, Peru is known for its various products made with quality cotton, t-shirt being the most representative product and with the highest production in the Peruvian industry. Despite this in recent years it has been losing share in both the international and domestic market due to products mainly from China and Bangladesh. During the first semester of 2020, the participation of national textile products represented only 2.9% of the Peruvian market, while imported products had a participation of 97.1%, causing a 78.7% decrease in sale of the national clothing industry (Produce 2020). The common problem identified, according to the review of the literature, of the SMEs that cannot be competitive in the market is the low level of service the offer, failing to comply with the quantity and delivery time of orders. Generating economic penalties and inconvenience. Customers in recent years prefer foreign textile products that has been growing progressively in the last decade. The motivation to carry out the research is reflected in the need to improve the level of service of a Peruvian t-shirt manufacturing company through the integration of various techniques that are mostly applied individually to solve various problems related to the low level of service, such as the SLP focused on solving the inefficient distribution of the plant, the TPM that allows increasing the efficiency of the machinery and the 5S methodology focused on reducing search time and eliminating other waste. For this reason, a combined model is proposed implementing the 5S, TPM and SLP tools that empower textile SMEs to comply with the delivery of orders on time and complete to their customers, and thus achieve an increase in the level of service in the sector that allows them to compete in the Peruvian market.

1.1 Objectives

The main objective of the research is to contribute to the use of a model that allows the SMEs of the Peruvian textile sector to increase the level of service. In this way, it is proposed to integrate tools that guarantee the reduction of downtime caused by unnecessary transfers, machinery breakdowns and the proposed model will contribute to future research on the same line to achieve the continuous improvement of companies in the Peruvian textile sector and thus can compete nationally and internationally.

2. Literature Review

For this chapter it is necessary to collect scientific articles related to the project to better understand the development of the proposed model.

2.1 Application of improvement models in the textile sector

In the manufacturing sector, the importance of textile SMEs is unquestionable, but the deficiencies in the use of tools to improve their level of service prevent sustainable growth and harm the national economy, since order fulfillment is a fundamental factor for any company, since it allows to satisfy the needs and requirements of the clients. Therefore, being an industry of great importance, it is necessary that the implement combined techniques to solve the multiple problem that they present and achieve the objectives. On the one hand, Carrillo et al. (2021) developed a model using Lean tools such as SMED, 5S, Kanban and standardization based on Demings continuous improvement in a textile company with the objective of increasing the service level from 56% to 63% avoiding cost overruns and penalties with the customers by improving production efficiency. On the other hand, Quispe et al. (2020) implemented a combined model using the TPM and SLP tools in a Jean garment company, obtaining as a result an increase of 16.1% in the general efficiency of the machine and reduction of 13.09% in the average travel time. For this reason, an optimal implementation of the combined techniques not only allows to reduce costs, but also allows to streamline the production process, reduce delivery time, and improve conditions in the industry.

2.2 Application of the 5S methodology

The 5S philosophy helps to maintain order and cleanliness in the work areas by eliminating waste, which allows increasing the efficiency, productivity, and profitability of the company. In the clothing industry, the implementation of the 5S methodology focuses on keeping the work area with more space and the tools located in specific places. This helps reduce travel time and search time by streamlining the production process (Alasbali and Almaktoom 2022). In a case study in a manufacturing company, the 5S methodology was implemented, emphasizing the steps of classifying and ordering, obtaining as a result a reduction in search time from 31 minutes to 7 minutes and an increase in punctual delivery of orders from 69% to 96.5% (Del Rosario et al. 2023). In addition, in another case study in a textile company, the application of 5S in tis warehouse allowed the level of service to be increased from 55% to 75% (Marin et al. 2022).

2.3 Application of Systematic Layout Planning

The Systematic Layout Planning methodology helps companies to optimize the distribution of work areas based on quantitative criteria, solving problems such as high travel time, operator effort, distance traveled and low production. Authors recommend the use of the SLP to the SMEs of the textile sector for its simple implementation, since for its reason for being they do not usually use engineering tools. In a case study, the implementation of the SLP in a textile company allowed to improve the standard production time and reduced transportation time, achieving a significant growth of 12% in production (Saenz et al. 2023). In the same way, in another case study in a backpack production plant, the SLP obtained positive results in the cycle time that was reduced from 33.64 minutes per backpack to 25.32 minutes, which allowed raising the level of compliance with 37% to 86% (Ruiz et al. 2019).

2.4 Application of Total Productive Maintenance

Different studies identify transcendental problems in manufacturing companies such as extremely high maintenance costs, emergency repairs that mean a high cost compared to the real cost and equipment downtime generating low productivity and competitiveness of companies (Gallesi et al. 2019). Schindlerova et al. (2020) indicates that maintenance and repair costs vary between 15% and 40% of total operating costs, therefore they implemented the TPM tool in an engineering company, obtaining results in reducing downtime by 40%- In addition, the highlight and emphasize the pillar of autonomous maintenance that allows increasing the worker´s morale by improving their awareness of the optimal use of maintenance. Similarly, Garrido et al. (2022) implemented the TPM tool in a plastic company, allowing to reduce the stoppage rate by 55.48% and increasing the level of order fulfillment by 74.59% through the implementation of formats, standardization of cleaning and lubrication of the machinery and a training plan. Likewise, one of the main indicators of this tool is the OEE introducer by Seiichi Nakajima, which allows measuring the efficiency of industrial equipment (Schiraldi and Varisco 2020). Amiel et al. (2022) implemented TPM in a textile company, allowing to reduce downtime by 23% and improve the OEE indicator from 46.90& to 60.18% focusing on the pillars of preventive and autonomous maintenance.

3. Methods

After a literature review, the most appropriate tools are chosen to start with the development of the model that can be seen in Table 1.

Table 1. Comparative matrix of the components of the proposal vs state of the art

Author and ref	Inefficient distribution of work areas	Frequent machinery breakdown	Clutter in the work area
Lista, A., Tortella, L., Bouzona, M., & Romroe, D. (2021)	SLP		
Quispe, H., Takahashi, M., & Carvallo, M. (2020)	SLP	TPM	
Ortiz, J., Aguilar, E., Rojas, J., Torres, C., & Raymundo, C. (2022)			5S
Baldeon, T., & Malasquez, P. (2021)			5S
Proposal	SLP	TPM	5S

3.1 Proposed model

The Figure 1 shows the proposed model allows to increase the level of service of the company, reducing the non-compliance of orders by term and quantity agreed with the client. To achieve this, you must go through different phases. The first phase is the analysis that implies knowing the current situation of the company from the interpretation of the data obtained with the help of the VSM, Pareto diagram, problem tree and current KPIs. The second phase is the implementation of the Systematic Layout Planning, 5S and Total Productive Maintenance tools that together help the company to increase the level of service by complying with the quantity and term of the order. Finally, the third phase is the evaluation of the KPIs and seek continuous improvement to maintain a high level of service in the company.

Model Stage. This section details the stages of the proposed model.

Stage 1: Analysis. In the analysis, the main indicators are determined for their subsequent evaluation that will allow the impact of the model to be measured- In addition, the following tools will be used: Value Stream Mapping that allows an overview of the processes and their time, a problem tree that identifies the main problem with its root causes and a Pareto Chart that orders the main causes according to importance.

Stage 2: Development. The development begins by implementing the SLP tool that will focus on efficiently distributing the company work areas, which are the following: warehouse area, cutting area, sewing area, and finishing area. To do this, the interrelation of the activities and travel time of the operators must be analyzed to design an optimal distribution of the work areas. Then the chosen Lea tools are implemented, which are 5S and TPM. On the one hand, the 5S methodology allows the company to reduce the high unproductive time generated by the lack of organization of the work area. For its implementation, it is important to carry out an initial and final audit to demonstrate the improvement and advances of the tool. On the other hand, the TPM technique focuses on reducing the problems of frequently occurring machine breakdowns. To do this, the tool focuses on the pillars of autonomous and preventive maintenance, empowering operator so that they can make decisions when a failure occurs and creating machinery cleaning and lubrication plans.

Stage 3: Evaluation. Finally, in the evaluation stage, the initial KPIs are contrasted with the values obtained after implementation. In this way, it will be possible to measure the impact and determine if the implementation of the model is successful or if other tools are needed to solve the main problem.

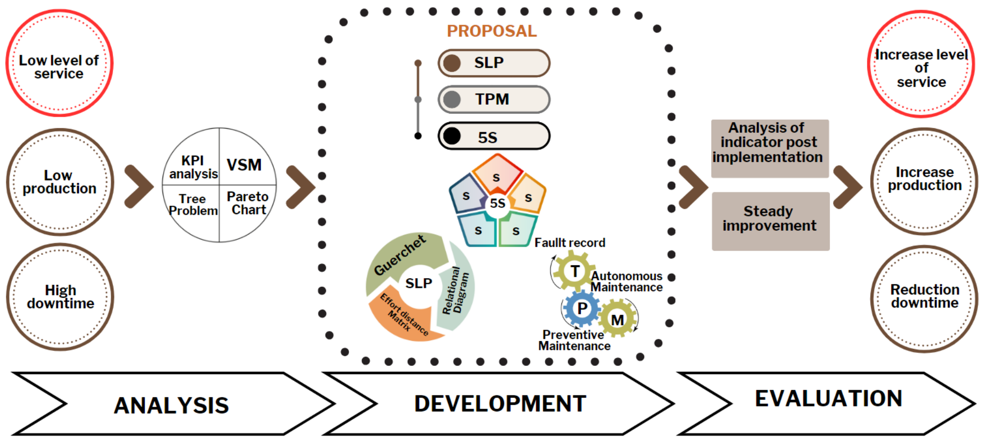

Figure 1. Proposed improvement model

Model Indicator. The following indicators will allow evaluating the performance and improvement of the tools used.

On time in full (1). Main indicator of the investigation that measures the deliveries of orders in the correct period and correct quantity to the client. Currently the OTIF of the company is 67%, it is intended to reach a value of 95%.

$$OTIF = \frac{number\ of\ delivries\ on\ time, in\ full}{total\ numer\ of\ deliveries}\ x\ 100\% \ldots (1)$$

Overall equipment effectiveness (2). Indicator that measures the performance of the machinery used in the production process and is obtained by multiplying 3 factors: performance, availability, and quality. The current value of the OEE is 69.05%, it is intended to reach a value greater than 85%.

$$OEE = Perfomance\ x\ Availability\ x\ Quality \ldots (2)$$

5s compliance (3). Measure the progress of the implementation of 5S in the company. Currently, compliance with 5S is 36%

Production capacity (4). Indicator that allows measuring the units produce daily in the company.

Travel distance (5). Indicator that measures the distance traveled between the different work areas of the company.

$$Travel\ distance = \sum Distance\ between\ work\ areas \ldots (5)$$

4. Data Collection

In the first phase of the model, it was possible to collect data from the company through interviews with supervisors, a diagram of the process operations and commercial information to know the current situation, where the problem was identified, the root causes and their solutions that can be observed in Figure 2.

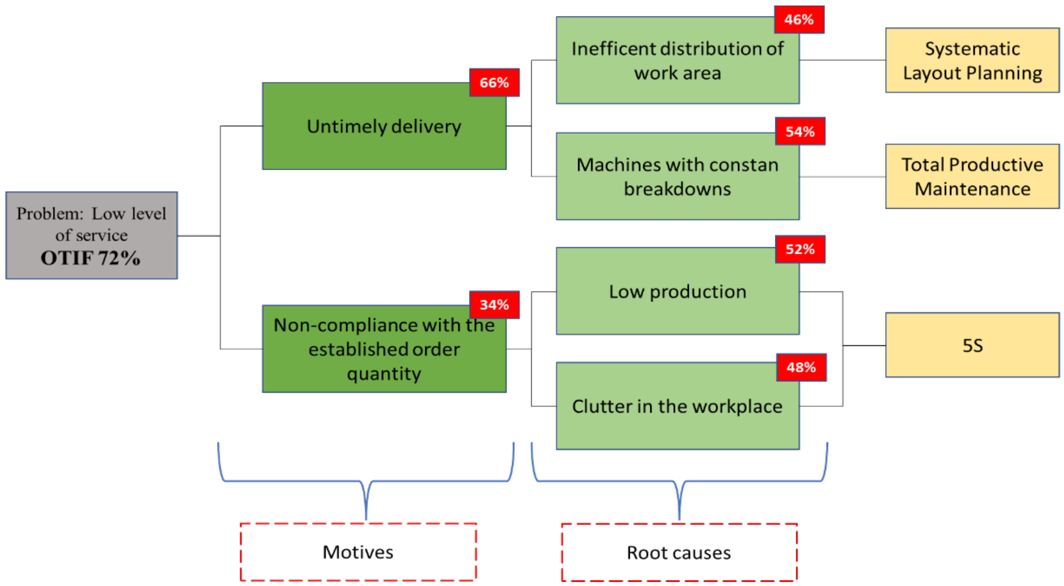

Figure 2. Problem tree

Additionally, data was collected for the development of the Guerchet method to determine an optimal location of the different work areas. For this, the dimension of the fixed elements of the plant were measured, which can be seen in Table 2.

Table 2. Dimension of the fixed elements

Element	Long	Broad	Height	Amount
Cutting and laying tables	14.75	2.15	0.85	2
Cutting machine	0.35	0.28	0.50	1
Straight machine	1.25	0.84	1.50	5
Coating machine	1.34	0.92	1.55	2
Overlock machine	1.20	0.83	1.50	13
Tool rack	1.80	0.80	1.25	1
Enabled table	5.80	3.40	0.82	1
Finishing table	5.80	3.40	0.82	2

Once the dimensions of the machines are obtained, the spaces required for each area of the plant are calculate. Table 3 calculates the static surface, surface gravitational, surface evolution and surface total.

Table 3. Guerchet method

Element	SS	SG	SE	ST
Cutting and laying tables	37.71	63.43	34.25	258.774
Cutting machine	0.098	0.098	0.07	0.53
Straight machine	1.05	1.05	0.76	14.28
Coating machine	1.23	1.23	0.89	6.71
Overlock machine	0.99	0.99	0.72	35.22
Tool rack	1.44	1.44	2.07	4.95
Enabled table	19.72	39.44	21.30	80.46
Finishing table	19.72	39.44	21.30	160.92

The cutting table and cutting machine belong to the cutting area, the straight, covering, overlocking machine tool rack, and enabling table belongs to the clothing area and the finishing table belong to the finishing area. In addition, Figure 3 shows the inefficient distribution of work areas without a logical sequence that causes necessary travel. Currently, the company's average traveled distance of 85 meters.

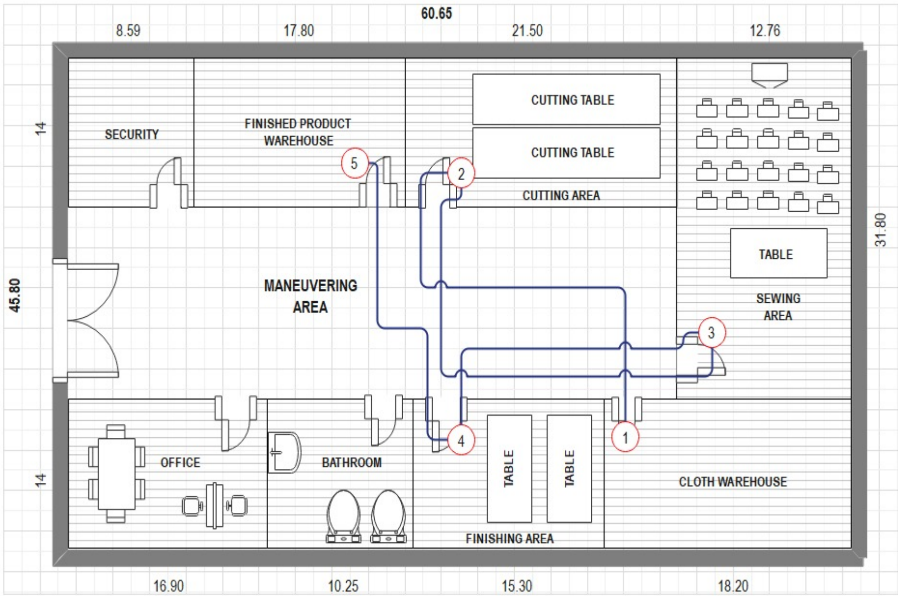

Figure 3. Distribution of work areas

5. Results and Discussion

5.1 Numerical Results

The application of the proposed model was carried out by means of a pilot test and simulation. On the one hand, the 5S and TPM tools were carried out through a pilot test. The 5S audit was carried out to reduce search time and maintain order and cleanliness in the sewing area, its impact being reflected in the reduction of search time from 7 minutes to 4.58 minutes and in increasing compliance with 5S from 36% to 72% that its progress can be seen in Table 6.

For the TPM technique, results were reflected in the OEE indicator, which initially was 69.05% and improved to a value of 86.19%. Table 4 shows the initial values and after the implementation of the component for the calculation of the OEE indicator.

Table 4. OEE calculation

Situation	Availability	Quality	Performance	OEE
Initial	87.14%	89.95%	88.09%	69.05%
Proposal	95.10%	94.56%	95.84%	86.19%

Finally, the SLP tool was valeted through a simulation, resulting in an increase in daily production capacity from 147 t-shirt to 163 t-shirts and a reduction in the distance travelled from 85 meters to 29 meters due to an optimal layout of the plant that was can be seen in Figure 4.

5.2 Graphical Results

Next, Figure 4 shows the new plant distribution considering the results of the Guerchet method.

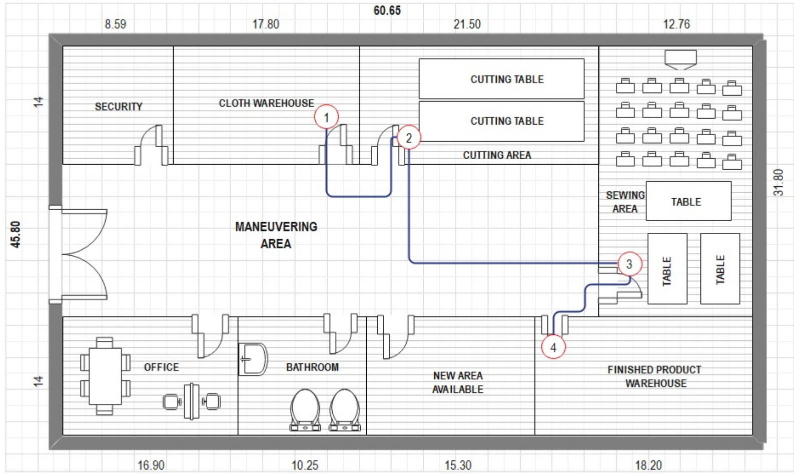

Figure 4. Improved area distribution

As can be seen, the finishing area was integrated into the sewing area, since through the Guerchet method and visual analysis it was shown that the sewing area has enough space for the 2 finishing area tables. In addition, the warehouses for fabrics and finished products were poorly located, which is why they were exchanged places. Both measures were carried out to minimize the travel distance and streamline the production process, since the current distribution present a logical sequence aligned with the production flow. The benefits of the proposal can be seen in the Table 5.

Table 5. Indicator comparison

Observed metrics	Initial situation	Improved situation
Travel distance	85 meters	29 meters
Effort	234 020 kg-m	75 192 kg-m

Figure 5 shows the improvements in the sewing area because of the implementation of the 5S methodology.

Figure 5. Improvements implemented

5.3 Proposed Improvements

The improvement after the implementation of the SLP, TPM and 5S are observed in Table 6.

Table 6. Proposed improvements after model implementation

Observed indicator	Initial situation	Situation after implementation	Variation
OTIF	72%	97%	Increase in 35%
OEE	69.05%	86.19%	Increase in 24.82%
Production capacity	147 unit / day	163 unit / day	Increase in 16 units
5S compliance	36%	72%	Increase in 36%
Search time	7 minutes	4.58 minutes	Decreased in 2.42 min

5.4 Validation

The model was valeted through two forms: pilot test and simulation through the arena program. The pilot test was used for the implementation of the 5S methodology to reduce the time and improve the use of resource in the manufacturing process. The tool made it possible to eliminate unnecessary objects in the work area, delimit the work areas, improve cleaning, and specifically mark the work tools. To verify the improvements in each "S", Seiri, Seiton, Seiketsi and Shitsuke.

Below, Table 7 shows the improvement percentage obtained in each audit.

Table 7. 5S audit results

Concept	Scale (1-5)	%
Initial diagnosis	1.82	36%
Control N°1	2.80	56%
Control N°2	3.04	60%
Control N°3	3.26	64%
Control N°4	3.39	67%
Control N°5	3.76	72%

The second validation method was chosen to carry out a simulation in the Arena software to evaluate the combined operation of the SLP, 5S and TPM tools where all the t-shirt production processes detailed in the Figure 6 were initially represented. The simulation begins with the arrival of the fabric and ends with the transfer to the finished products warehouse. One the initial model is made, the proposed improvement model is represented, observing an improvement in transfer times and machine processes. In addition, the Figure 7 shows the elimination of the transfer of the sewing area to the finishing and cleaning area. Once both models, initial and final, were obtained, a pilot simulation was carried out with a run of 30 repetitions and then the minimum repetitions were calculated, determining 378 repetitions for the initial model and 167 repetitions for the improved model. Then we proceed to analyze the proposed indicator using the Output Analyzer software to evaluate the impact of the proposed improved model.

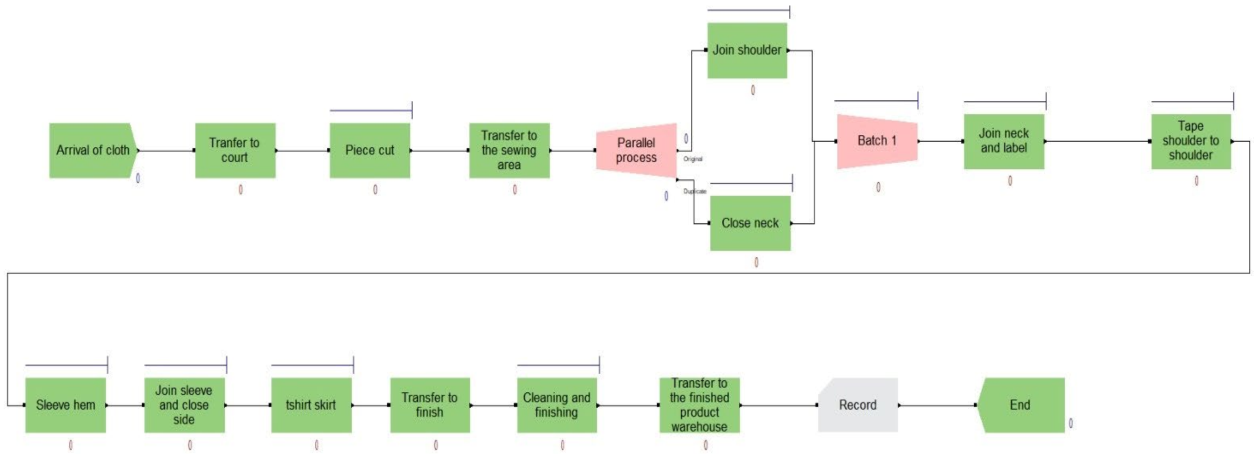

Figure 6. Initial model

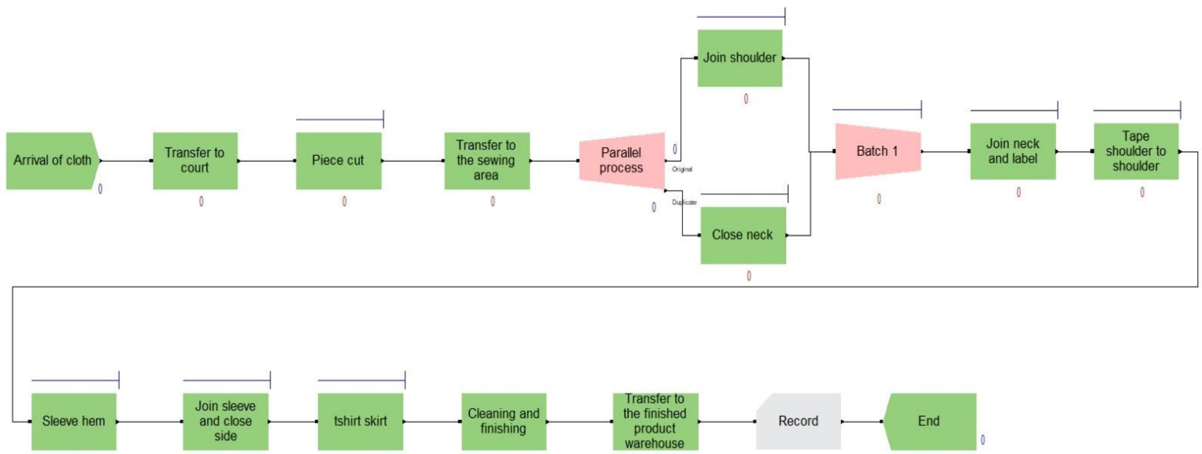

Figure 7. Improved model

6. Conclusion

The application of the 5S tool contributed to the reduction of search times from 7.58 min to 4 min, thus increasing the performance of each operator. Based on this indicator, we can conclude that the application of the 5S methodology contributes to improving the efficiency and performance of companies in the textile sector. The implementation of TPM greatly increased the efficiency of the equipment from 69.05% to 86.19%, which influences the availability of the machine, the efficiency, and the quality, which increased its production performance through the improvements implemented. The SLP technique reduced unnecessary transfers from one work area to another, making it possible to streamline the manufacturing process and reduce the operator's effort. Finally, the use of the 3 tools together allowed to raise the level of service of the company that initially was 72% and applying the proposed improvement model increased to 97%.

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Biographies

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Martín Collao-Diaz at ESAN University and Industrial Engineer from Universidad de Lima specialized in supply chain management and operations. A leader with more than 25 years of local and international experience in national and multinational companies in industrial, hydrocarbon, and mass consumption sectors. Broad experience in supply chain management (purchasing, inventory, suppliers and supply sources management, logistics: transport, distribution, and warehouse management), operations (planning and control of production and maintenance), and integrated system management (ISO 9001, ISO 14001, and OHSAS 18001). Business alignment based on sales and operations planning (S&OP). Besides, continuous search for improvements in profitability based on process optimization and saving projects using tools such as Six Sigma methodology, among others, focused on being a High-performance Organization (HPO). Development of a high-performance team. Member of IEEE and CIP (College of Engineers of Peru).