Production Management Model to Reduce Production Costs Using the SLP Technique in the Curtain Making Process: Textile Sector Case

Renzo Sebastián Bernaola Vara and Raúl Alejandro García Ruiz
Facultad de Ingeniería y Arquitectura, Universidad de Lima, Perú
20162868@aloe.ulima.edu.pe, 20163118@aloe.ulima.edu.pe

Carlos-Augusto Lizárraga-Portugal
Research Professor
Facultad de Ingeniería y Arquitectura, Universidad de Lima, Perú
clizarra@ulima.edu.pe

Abstract

Currently, in the textile sector there are different opportunities to improve productivity and reduce production costs originating from various factors such as excess waste and waste of materials, delay in manufacturing and delivery of orders with negative effects on income. of the company. The objective of the research is to develop a production management model to reduce production costs in the curtain making process of a textile mype in the city of Lima, Peru, using an empirical research design, from a quantitative approach to explanatory level in the case study modality, presenting an engineering solution model validated through simulation techniques. A diagnosis of the situation found was made by applying the Value Stream Mapping (VSM) technique; accompanied by an analysis of the root causes of the identified problems and the analysis of research background on the subject, the System Layout Planning (SLP) technique was selected as a solution tool. The solution model was validated through the simulation technique using the Arena software, finding that production costs decreased by 3.74% compared to the initial situation.

Keywords
Production management, installed capacity, Value Stream Mapping, System Layout Planning, textile sector.

1. Introduction
In Peru, according to estimates from the Sociedad Nacional de Industrias (SNI), the textile and clothing industry is the third activity with the highest contribution to manufacturing PBI, at 6.4% as of 2019, and it is estimated that it generates 398 thousand direct jobs per year and 900 thousand jobs; and according to the Superintendencia Nacional de Administración Tributaria [SUNAT] as of 2018, the sector was made up of 93,861 productive units, of which 99.9% corresponds to micro and small companies, mype (Instituto de Estudios Economicos y Sociales [IEE] 2019). The production of the textile and clothing sector gradually decreased by 32.1% compared to 2012 as a result of factors such as increased competition with low-cost imported products as well as limiting factors in the sector such as lack of planning, waste of resources, reprocesses, excess movements, lack of space and others (Larios-Francia 2017); problems that increased between 2021 and the beginning of 2022 as the demand for their products increased and therefore delays in delivery were generated, which affected customer dissatisfaction (Ames et al. 2019).

The industry with low value of added labor and intensive labor, such as the textile sector, must take certain measures of attention in terms of improving production, efficiency and productivity (Parida and Pradhan 2016). In this sense, it is important that in order to achieve lower costs, it is necessary to have a good design of facilities, guaranteeing a greater use of space to effectively employ labor. This also implies that the operators carry out the work determined by the companies in the agreed times so that they generate maximum use, taking into account that the work carried out by the personnel must be valued and highlighted in a good way to improve the production of the company and thus obtain greater profitability (Jaimes et al. 2018).

1.1 Objectives
The general objective of the study is to develop a production management model to reduce production costs using the System Layout Planning (SLP) technique in the process of making curtains in a Mype in the textile sector:

- Elaborate the diagnosis of the production area to determine possible problems and their root causes.
- Propose the best solution and the production management model to carry out the improvement actions.
- Develop the proposed improvements and compare the changes in the analyzed metrics.
- Validate the proposed model in different scenarios through simulation with the Arena software.

2. Literature Review
In the country, the companies dedicated to the textile sector are mostly MYPES, which are characterized by having low levels of productivity and efficiency in production, since they do not have a system for organizing work areas and process optimization (Quispe-Roncal et al. 2020). It is understood and identified that the processes and activities carried out so that the curtains can be manufactured in accordance with the specifications required by the client, can optimize the entire value chain (Rau and Mejía 2019).

Likewise, it must be taken into account that in order to provide an optimal and clear solution to production problems, it is necessary to have certain methodologies in order to develop an improvement in efficiency. Also, it was possible to analyze that, for a better use of production resources, it is important to have a good design of the layout of the plant using techniques such as 5S, Kanban, Just in Time (JIT), among others, achieving improvements in the production process and a 54.39% reduction in order delivery time (Montalvo-Soto et al. 2020).

It was observed that the reasons why they use some of these tools is because they come to solve the design problem of manufacturing industries and improve the manufacturing scenario, maximizing benefits or minimizing costs at optimal levels of production, production capacity. inventory and shortages (Ruiz et al. 2019).
In general, they have little manufacturing space for their production, since they are designed without taking into account their efficiency; that is why it faces a huge production cost due to low operator outputs, low inefficiency, unnecessary movements and production delays. In this way, to achieve lower costs, it is necessary to have a good design of facilities, guaranteeing a greater use of space to effectively employ labor. (Campo et al. 2020).

The production process is defined as a set of operations that combines a series of factors to produce a good and/or a service. These operations are consecutive and planned to transform the raw material into the final product, so that each production process requires specific planning, due to the details regarding the process, raw material, number of activities, costs, etc. Currently, there are various techniques to improve these processes and thus companies are more competitive. In this research we can find the System Layout Planning (SLP) technique, which focuses on the application of methods and tools in order to optimize processes and organize work areas (Quispe-Roncal et al. 2020). Furthermore, continuous incremental innovation is reflected in activities of short duration, high frequency, rapid change cycles, which alone have low impact; but accumulated they can make a significant contribution to performance (Aldea Molina 2021). Likewise, it is described that the manufacturing industry presents responsibilities and threads that involve both managers and production workers with the aim of producing a quality product for the consumer at a low cost (Paredes 2018). The study over time reveals that there are different perspective approaches according to each author; However, they are all based on a central idea: the systematic analysis of activities and process flows with the aim of improving them. (Flores et al. 2019).

In addition, due to the fact that the company's main problem is the increase in production costs, one of the variables with the greatest impact on any company; the organization under the criterion that the price cannot be controlled directly, since the market imposes referential ceilings on prices, a factor that is directly linked to sales volume. For this reason, a cost system must be delimited that allows the company to maintain control of production costs and thus plan business objectives (Ali Naqvi et al. 2016). Finally, a poor layout of the plant makes it difficult for the company's operators to carry out activities according to a set time; this generates delays in deliveries and accumulation of raw material (Sarmiento et al. 2017). Therefore, not having an established production process generates waste of time and poor organization in the space that the company has to carry out its operations (Flores et al. 2019); for which it was decided to use the System Layout Planning (SLP) methodology to be able to carry out continuous improvement, achieve a process management approach and a culture of continuous improvement for the company (Ramos et al. 2018). In addition to also using the VSM tool which allows to obtain a better diagnosis of the production flow (Malpartida et al. 2021).

The PDCA Cycle is a fundamental method for the planning, implementation and continuous improvement of management systems and their processes, improving results and reducing possible resulting risks. (Stefanova-Stoyanova and Danov 2022)

3. Methods

The design of the research that has been developed is empirical, because it was based on concrete and verifiable evidence taken from practice, analysis and systematization (Rodríguez and Pérez 2017). Starting from the specific information of an SME in the textile sector focused on the production of curtains, the study was carried out under the case approach. For the present work, a quantitative approach was used, since it describes, measures, explains and predicts specific phenomena of nature through concrete, solid and reliable data to guarantee its objectivity (Herrera 2019).

3.1 Proposed improvement model

In order to have a better understanding of the implementation of the improvement program in its different phases and stages, the following Solution Model was developed from the data mentioned above. See Figure 1.

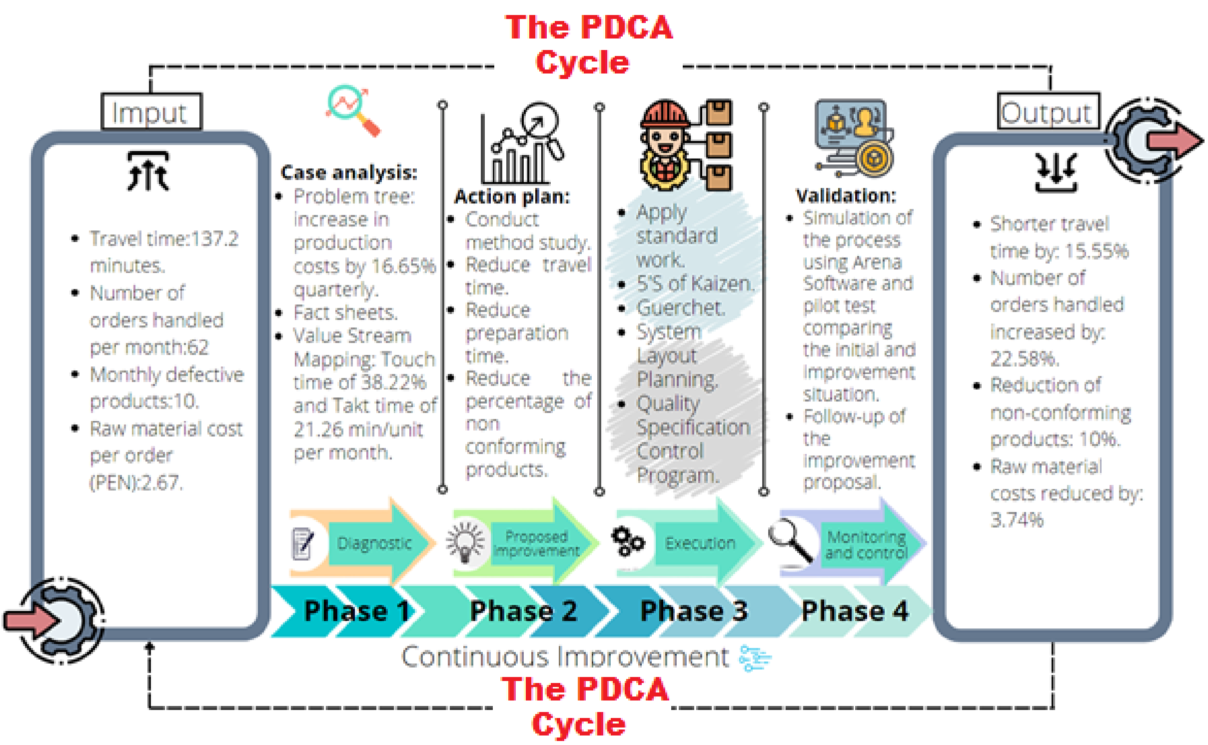

Figure1. Improvement model proposed for the curtain manufacturing company.

A model was developed to improve the cycle time of the production process, reduce defective products and reduce production costs by applying the Plan-Do-Check-Act (PDCA) cycle method, carrying out continuous improvement in each phase of development: diagnosis, process improvement, execution, as well as monitoring and control, as explained below:

Phase 1, diagnosis: it is made up of the diagnosis through the process tree, the company's technical files previously analyzed and validated with the production manager and with the Value Stream Mapping tool, where a high Lead Time was identified in the warehouse of transit of raw material having six hours of cycle time, a high level of defective products in the operations of cutting and placing eyelets and a bottleneck was identified in the sewing area due to the fact that the preparation time is very high, also the real time that the team works on a task or touch time of 38.22% was identified. In addition, the production process rate was obtained to satisfy the takt time demand of 21.26 min/uni. See Figure 2.

Phase 2, improvement proposal: the improvement proposal for the company was prepared through the action plan focused on the study of methods, reducing travel times, reducing order preparation time and reducing the percentage of non-conforming products.

Phase 3, execution and control: the standard work was applied to provide a structured routine to the production personnel to execute their tasks in a more productive and efficient way (Santa María and Suarez 2021), the distribution and plant reorganization tools, Guertchet and the Kaizen methodology of the 5's. In addition, a quality control program was implemented to ensure that the processes meet the desired standards (Calderón et al. 2019).
Phase 4, validation and follow-up: it consists of the validation of the proposed improvement through simulation with the Arena software and the follow-up and control of the action plan.

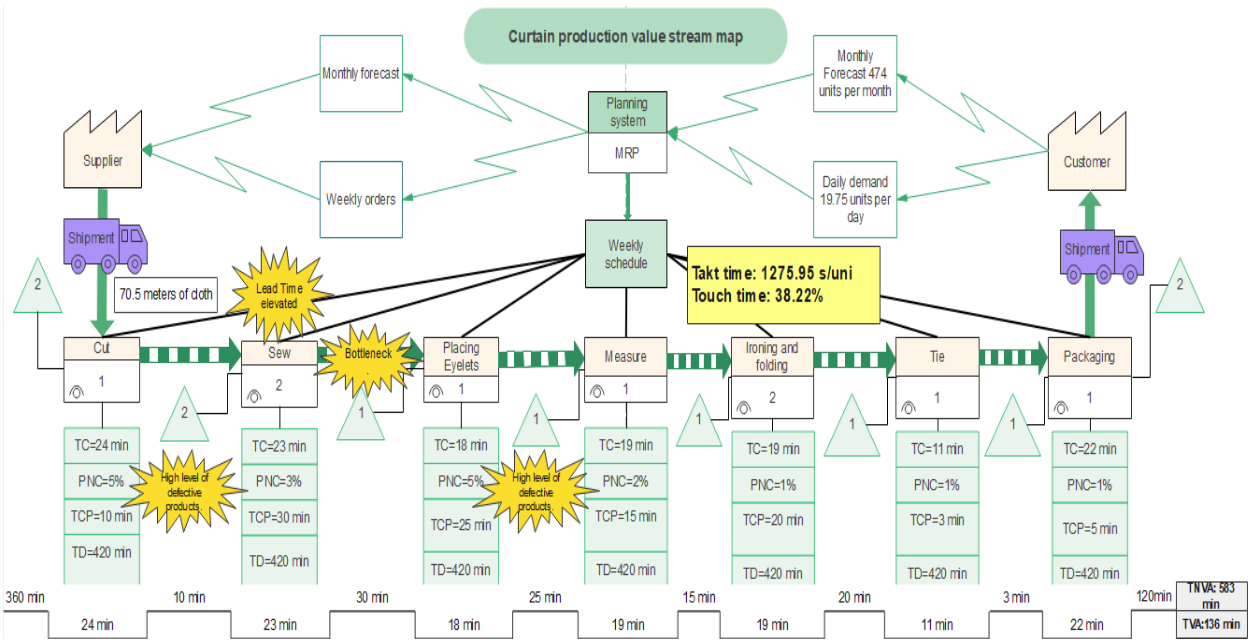

Figure 2. Value Stream Map of curtain production.

4. Data Collection

The first phase of the article is based on the specific data that the company in the textile sector has given us through the technical sheets, interviews and sales reports to make the appropriate observations; specifically in the management of production costs, where we identify the problems, effect, reasons and the corresponding solutions to reach the goal of reducing production costs for the development of the problem tree, which includes the data mentioned above. See Figure 3.

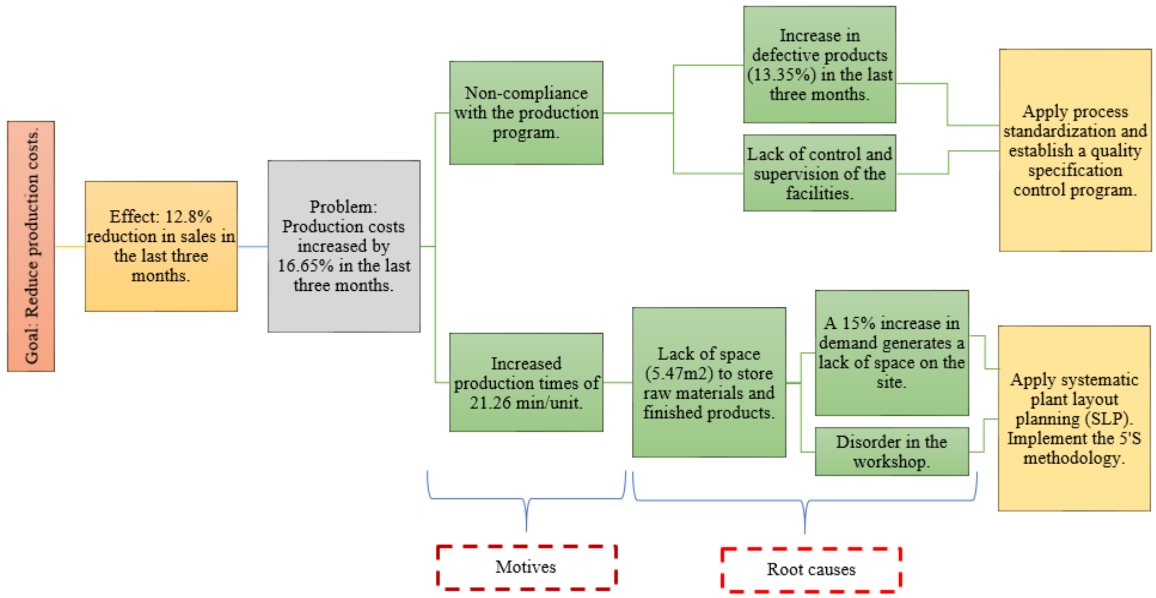

Figure 3. Problem tree of the curtain making process

In addition, after the elaboration of the Value Stream Mapping, it was possible to obtain the following metrics of the curtain elaboration process to identify opportunities for improvement in each activity involved, point out the waste generated in the operations and reduce the cycle times of the process. For the diagnosis, a monthly production of 474 units was taken. Following this, phase two was given, which is the implementation of the action plan based on the metrics obtained from the VSM. See Table 1.

Table 1. Proposed action plan for the textile industry company.

Process	Metric	VSM current	Action plan	Tool
Cut	Tc> Tkt	24 > 21.2 s/u	Conduct method study	Apply process standardization.
warehouse in transit	High lead time	6 hours	Reduce the time of raw material storage and routes	5s, SLP y Guertchet
To sew	Time of preparation	30 minutes	Decrease preparation time	5s, SLP y Guertchet
Cut and place eyelets	% Product not compliant	5%	Reduce the % of non-conforming product	Establish a quality specification control program

In phase 3, the following data were collected for the use of Guertchet's methodology. The static machines that the textile sector company has are 4 and the mobile ones are 1. Once the dimensions have been made, the appropriate calculations are made to obtain the recommended area. See Table 2.

Table 2. Calculation of required surfaces-Guertchet Methodology

Machines	St	Ssn x nh	Ss x n
Industrial Straight Sewing Machine	9,99	1,92	2,40
Overlocking machine	4,99	0,96	1,20
Iron	0,16	0,00	0,04

Die cutting machine	0,33	0,04	0,08
Operators	-.-	4,25	2,5
Total	15,47	2,92	3,72

In order to calculate the required spaces of the production area, the Guertchet method was used, using this tool is necessary to identify the total number of operators and the total number of machines. The following equation was used:

- Static surface (Ss) Ss = Largo * Ancho
- Gravitation surface (Sg) Sg = Ss * N
- Evolution surface (Se) Se= (Ss + Sg)* K

The route diagram is responsible for showing the route of the product, these are characterized by symbols of operations, transport, delay, inspection and warehouse. As can be seen in the diagram of the company's current route, it has an area of 10 square meters. See Figure 4.

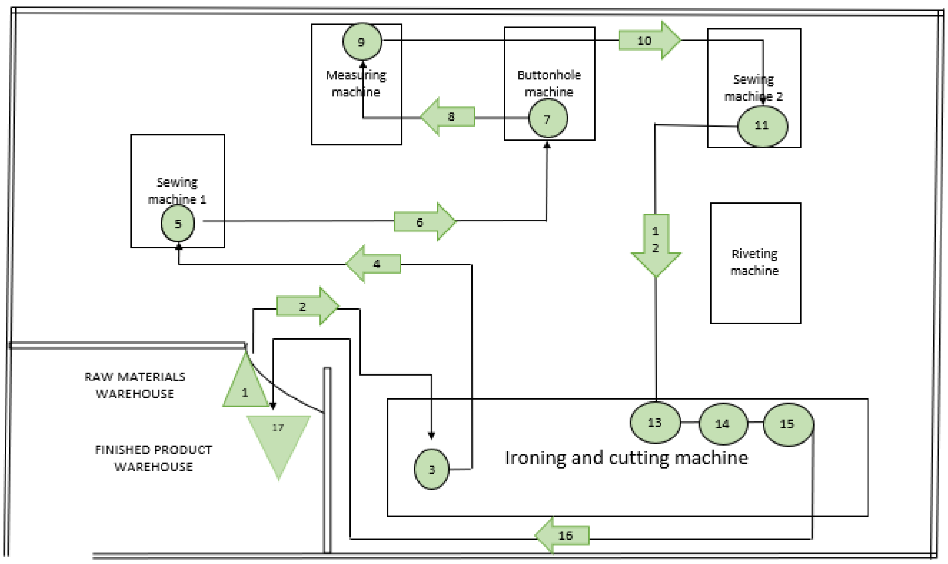

Figure 4. Current path diagram (as is)

You can observe the steps that are carried out in each activity of the production of curtains, managing to identify the inefficiencies of the production process and the delays in the operations to eliminate them or adjust the times of each one of them to improve efficiency, respectively. The current situation of the company, has 8 operations, 7 transports, 3 verifications and 2 warehouses; obtaining 137.2 minutes to carry out the entire production and 10 m^2 as total travel distance (see figure 5), verified through technical sheets provided by the organization, a time study and interviews that were prepared and collected during visits to the company (Andrade et al. 2019). See Figure 5

ANALYTICAL FLOWCHART	OPERATOR / MATERIAL / EQUIPMENT		
DIAGRAM No. 1 Sheet No. 1	SUMMARY□		
Object:	Activity	Current	Proposed
Activity:□ Method: CURRENT Place: Service and Decoration Plant	"Operation Transport Waiting Inspection Storage"		8 , 7, 0, 3, 2
Operator(s): 4 Sheet no: 1	Distance		
	Time		137,2
Composed by: Renzo Bernaola Date: 16/09/2022□ Approved by: Graciella Vara Date: 08/17/2022.	"Cost Labor Material"		

Activities	D (m)	T (min)	○	⇨	D	□	▽	Observations
Fabric in raw materials warehouse	0,3	0,3					●	Removing the MP fabric
Verify that the fabric is correctly stored	0,2	3				●		Verify that the fabric has no flaws
Transfer to cutting area	0,9	0,2		●				Carefully transfer the fabric
Cut fabric on cutting table	0,5	15	●					Carefully cut the fabric
Transfer fabric to sewing machine	1	0,2		●				Transferring the right cuts
Sew the curtain	0,6	27	●					Enter pelon and thread
Check that the fabric is sewn correctly	0,2	3				●		Check for stitching faults
Transfer to die-cutting machine	0,8	0,2		●				Moving the curtain with the eyelets
Place custom eyelets on the curtain	0,4	22	●					Careful die-cutting
Transfer the curtain to the measuring area.	0,7	0,4		●				Transfer with care
Measure curtain	0,4	12	●					Perform standard measurement
Transfer to sewing machine	0,9	0,2		●				Moving the measured curtain
Sew the curtain to the established measurement	0,4	27	●					Enter pelon and thread
Check that the fabric is sewn correctly	0,2	3				●		Check for stitching faults
Transfer the curtain to the ironing machine	0,8	0,2		●				Transfer the sewn curtain
Iron the curtain	0,2	15	●					Iron the curtain at standard temperature
Tie the curtain	0,2	5	●					Selvedges enter
Pack the curtain	0,2	3	●					Bags enter
Transfer to finished goods warehouse	0,9	0,2		●				Moved to PT
Finished products warehouse	0,3	0,3					●	Ready for delivery
Total	10,1	137,2	8	7		3	2	

Figure 5. Analytical diagram of processes of the current situation.

5. Results and Discussion

5.1 Numerical Results

By applying the improvement proposed in the Arena software simulation, taking a monthly production of 474 units, the following results were obtained. See Table 3.

Table 3. Metrics of the current model and the proposed solution (simulation)

Metrics	Current model	Proposed improvement model
Number of defective products in cutting and die cutting	10	9
Orders served	62	76
Total raw material cost per order	2.67 PEN	2.57 PEN

Cycle time in the cut (min)	22.67	17.62
Preparation time in sewing (min)	8.71	8.52

It is noticeable that after the application of the proposed improvement, the number of defective products in the cutting and die-cutting operations was reduced by 10%, the number of orders served increased by 22.58%, the cost of raw material was reduced by 3.74%, the cutting cycle time was reduced by 22.27% and the order preparation time for the sewing area decreased by 2.18%.

On the other hand, the implementation of the standard work methodology, the Kaizen 5's tool, the distribution of the plan and the SLP. With the latest methodology, it was possible to reduce the distance of the route and the time through the use of the route diagram and the Guertchet, with the 5S applied in the company, it was possible to make improvements in the classification, order, cleanliness, standardization and discipline, thus generating more pleasant and safer sites so that operators can work efficiently (Ruiz et al.2019). The processes were executed through the standard work so that they are carried out routinely, allowing to meet the client's demand with the operators that the company has.

5.2 Graphical Results

Next, the proposed route diagram for the curtain company was made, which gave us a total of 15.46 square meters according to the Guertchet method, rounding the area of the production plant to 16 square meters. See Figure 6

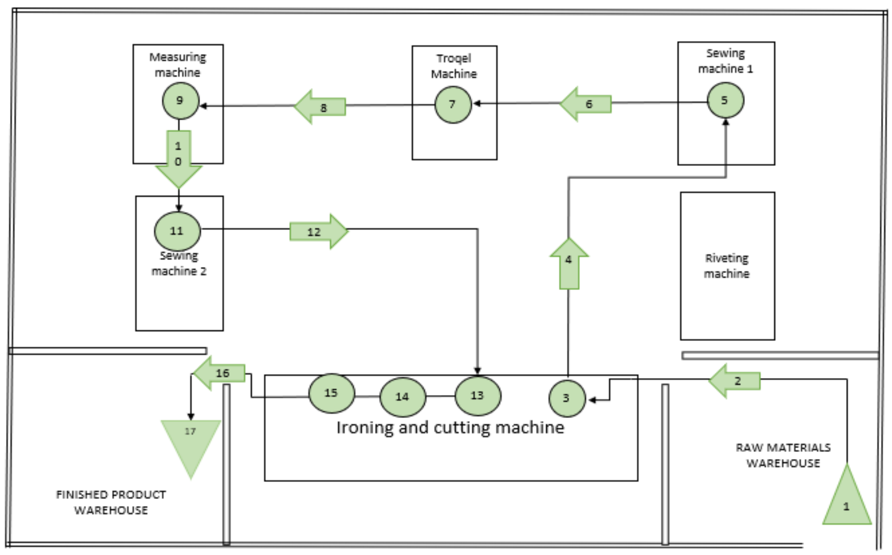

Figure 6. Flow diagram after the implementation of the improvement proposal (to be)

The activity diagram for the proposed solution model has 8 operations, 6 transports and 2 warehouses, generating a time of 121.86 minutes. Which if we compare the analysis diagram of the proposed process with the current one, it was observed that the time decreases in 15.34 minutes the production of curtains. See Figure 7.

ANALYTICAL FLOWCHART	OPERATOR / MATERIAL / EQUIPMENT□		
DIAGRAM No. 1 Sheet No. 1	SUMMARY□		
Object:	Activity	Current}	Proposed
Activity: Method:PROPOSED	"Operation Transport Waiting Inspection		8 , 7, 0, 0, 2
Place: Service and Decoration Plant	Storage"		
Operator(s): 4 Sheet no: 2	Distance		12.05
	time		121.86
Composed by: Renzo Bernaola Date: 09/29/2022 Approved by: Graciella Vara Date: 30/09/2022 Graciella Vara Date: 09/30/2022.	Cost labor material		

Activities	D (m)	T (min)	○	⇨	D	□	▽	Remarks
Fabric in raw materials warehouse	0.5	0.3					●	Remove the fabric from the PM magazine□
Transfer to cutting area	0.9	0.16		●				Carefully transfer the fabric
Cut fabric on cutting table	0.5	15	●					Carefully cut the fabric□
Transfer fabric to sewing machine	1.2	0.16		●				Transfer the appropriate cuts□
Sew curtain	0.5	25	●					Enter the thread and pelon in the seam□
Transfer to die cutting machine	0.9	0.16		●				Transfer the sewn curtain
Place custom eyelets on the curtain	0.4	22	●					Carefully make the die cut□
Transfer curtain to measuring area	0.9	0.3		●				Transfer to measuring area□
Measure curtain	0.35	10	●					Perform standard measurement□
Transfer to sewing machine	0.9	0.16		●				Transfer the fabric measurement properly done□
Sew the curtain to the established measurement	0.3	25	●					Enter the thread and pelon in the seam□
Transfer the curtain to the ironing machine	1.2	0.16		●				Transfer the sewn curtain
Iron the curtain	0.5	15	●					Iron the curtain at standard temperature
Tie the curtain	0.5	5	●					Using selvedges□
Pack the curtain	0.5	3	●					Bagging the curtain
Transfer to finished goods warehouse	1.5	0.16		●				Transfer to PT warehouse□
Finished products warehouse	0.5	0.3					●	Ready for delivery□
Total	12.1	121.86	8	7			2	

Figure 7. Activity diagram of the proposed solution model.

Regarding the quality control program, the internal audit process was carried out where the results are the average of the valuations that were obtained from each description and the objectives that the company must achieve. To perform the scoring in the audit process, it must be verified that the specific descriptions are meeting the clear objectives, for this it is distributed in 5 scales, which scale 0 does not meet the objective, scale 1 meets 20%, the scale 2 complies with 50%, scale 3 with 60%, scale 4 with 80% and scale 5 with 100%. You can see what description needs improvement, the objectives and averages of the curtain manufacturing process operations that were obtained. See Table 4.

Table 4. Description of the internal audit process in the production of curtains

.

Description	Objetive	Average
Select	5	4
Organize	5	3
Clean up	5	3.5
Standardize	5	4.5
Discipline	5	3

5.3 Proposed Improvements

The improvements proposed for the curtain manufacturing company after the implementation of the SLP, are the following. See Table 5.

Table 5. Improvements found after the implementation of the action plan.

Observed Metrics	Initial situation	Situation after improvement	Results achieved
Travel distance (m^2)	10.1	12.1	Increase in $2m^2$ the plant
Travel time (min)	137.2	121.85	It was reduced by 11.18%
Non-compliant products	10	9	10% reduction
Number of orders served	62	76	Increased by 22.27%
Raw material cost (PEN)	2.67	2.57	Decreased by 3.74%
Tiempo de ciclo de corte (min)	22.67	17.62	It was reduced by 22.27%
Preparation time in the sewing area (min)	8.71	8.52	Decrease in 2.18%

5.4 Validation

For the validation of the proposed improvement model, the Arena software was used simulating a monthly production of 474 units, the production was obtained by linear regression using the previous monthly sales from January 2021 to July 2022. The operations involved were placed in the simulation in the curtain production process, as well as the number of operators, machines, materials and work times, it should be noted that the information mentioned above was collected through technical sheets, interviews with company personnel and a time study. See Figure 8.

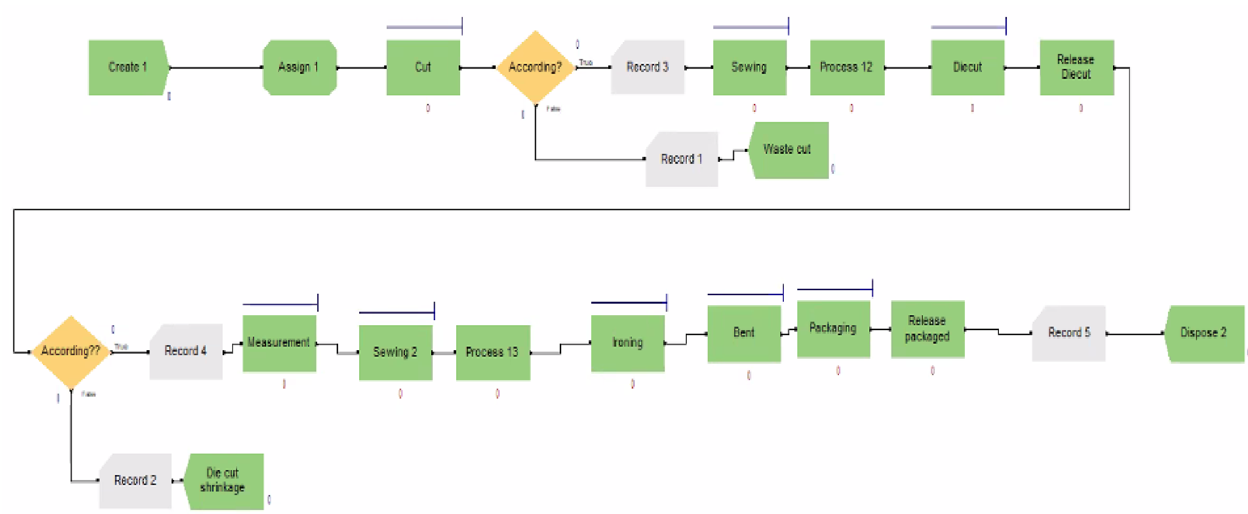

Figure 8. Simulation of the proposed improvement in the Software Arena.

The following data were obtained from the simulation of the proposed improvement: the total number of non-conforming products was 9 units, the waiting time in the sewing process was 8.52 minutes, the number of orders served increased to 76 units, the cycle time in the cutting process was reduced to 17.62 minutes and the production cost (PEN) was reduced to 196. In comparison, with the combined model of SLP and TPM proposed by Quispe-Roncal et al. (2020), the travel time had a reduction of 13.09% and the proposed improvement of this research by 11.18%, after which it is possible to rescue that our improvement proposal is in an acceptable range.

6. Conclusion

In relation to the general objective of the investigation, it is concluded that the implementation of the production management model using the System Layout Planning (SLP) technique generated that production costs were reduced by 3.74% due to the decrease in production and use delays. resource efficiently. It is essential that the personnel in charge of production planning have the skills and technological support to simulate the changes that may occur in the operations and to carry out the monitoring and improvements necessary for the proper application of the methodology. In relation to the specific objectives of the research, it was found:

Through the Value Stream Mapping (VSM) and the problem tree in the diagnostic phase, the most relevant problems of the curtain manufacturing process were identified, detailing the production metrics, to identify the improvements in each of the related activities; in addition, to generate an action plan that allows to solve the identified problems. It is advisable to review the literature proposed by other authors to have a better repository of possible problems that occur to companies in the textile sector.

Through the System Layout Planning (SLP) technique, a better distribution of the plant was achieved, improving the organization of spaces to facilitate more efficient production and a higher level of competitiveness of the company. It is recommended to use technical sheets and interviews with the organization's staff to contemplate the entire panorama that the company is going through.

The proposed model, when implemented, improved the initial situation of the company, achieving significant positive changes in the organization, thus managing to reduce the total time of operations by 15.34 minutes, travel time by 11.18%, non-conforming products in 10%, cutting cycle time by 22.27%, raw material costs by 3.74%, and increasing the number of orders by 22.27%. It is recommended to carry out a pilot test of the proposed model to show improvements in the action plan and that the detailed metrics continue with its development.
The validation of the improvement proposal through the Arena simulator helps to obtain future responses to the implemented changes without having to put the company at risk and to identify the processes that obtained a better performance compared to the current situation of the company. It is recommended to carry out the simulation with the extreme data of the range of orders to have results in all the possible scenarios that the company may encounter.

References

Aldea Molina, A., Influence of the Redesign of the Production Processes of a Flexible Packaging Company Based on Continuous Improvement, *Industrial Data*, vol. 24, no. 1, pp. 15–22, 2021.

Ali Naqvi, S. A., Fahad, M., Atir, M., Zubair, M. and Shehzad, M. M., Productivity improvement of a manufacturing facility using systematic layout planning, *Cogent Engineering*, vol. 3, no. 1, 1207296, 2016.

Ames, V., Vásquez, W., Macassi, L. and Raymundo, C., Maintenance Management Model based on Lean Manufacturing to increase the productivity of a company in the Plastic sector, *Proceedings of the 17th LACCEI International Multi-Conference for Engineering, Education, and Technology,* Jamaica, July, 24-26, 2019.

Andrade, A., Del Río, C. and Alvear, D., A Study on Time and Motion to Increase the Efficiency of a Shoe Manufacturing Company, *Información tecnológica*, vol. 30, no. 3, 83-94, 2019.

Calderón-González, G., Espinosa-Rodríguez, M. and Olvera-Rodriguez, A., Implementación de herramientas de calidad en una empresa textil del Bajío*, Revista de Tecnologías en procesos Industriales*, vol. 3, no. 7, pp. 6–11, 2019.

Campo, E., Cano, J. and Gómez-Montoya, R., Optimización de costos de producción agregada en empresas del sector textil. *Ingeniare. Revista chilena de ingeniería*, vol. 28, no. 3, 461-475, 2020.

Flores, L., Rojas, J., and Zúñiga, D., Production process improvement in a white goods appliances factory using lean six Sigma methodology, *Proceedings of the 17th LACCEI International Multi-Conference for Engineering, Education, and Technology,* Jamaica, July, 24-26, 2019.

Herrera, L., *Crecimiento de la industria textil peruana y su efecto en el nivel de empleo del sector: 2000 - 2012.* [Tesis para obtener el título de economista, Universidad Nacional de Trujillo]. Repositorio institucional de la Universidad Nacional de Trujillo, 2019

Instituto de Estudios Económicos y Sociales [IEE], Industria Textil y Confecciones - marzo 2021, Sociedad Nacional de Industrias, 2021

Jaimes, L., Luzardo, M., and Rojas, M., Factores Determinantes de la Productividad Laboral en Pequeñas y Medianas Empresas de Confecciones del Área Metropolitana de Bucaramanga, Colombia, *Información tecnológica*, vol. 29, no. 5, pp. 175–186, 2018.

Larios-Francia, R. P., Estado actual de las mipymes del sector textil de la confección en Lima, *Ingeniería Industrial*, no. 35, pp. 113-137, 2017.

Malpartida, J., Olmos, D., Quiñones, S., Ledesma, M., Garcia, G., and Diaz, J., Estrategia de mejora de procesos Six Sigma aplicado a la industria textil, *Revista de Investigación Científica y Tecnológica Alpha Centauri*, vol. 2, no. 3, pp. 72–90, 2021.

Montalvo-Soto, J., Astorga-Bejarano, C., Salas-Castro, R., Macassi-Jauregui, I. and Cardenas-Rengifo, E., Reduction of order delivery time using an adapted model of warehouse management, SLP and Kanban applied in a textile micro and small business in Perú, *Proceedings of the 18th LACCEI International Multi-Conference for Engineering, Education, and Technology,* Virtual Edition, July, 27-31, 2020.

Paredes, J., Gestión de producción y crecimiento económico de la micro empresa de producción textil en Riobamba – Ecuador, *Quipukamayoc*, vol. 26, no. 52, pp. 19, Riobamba, Ecuador, 2018.

Ramos, E., Velastegui, L., Carrasco, T., and Cepeda, E., Sistema de gestión de calidad y su impacto en la productividad del sector textil, *Visionario Digital*, vol. 2, no. 1, pp. 25–37, 2018.

Quispe-Roncal, H., Takahashi-Gutierrez, M., Cardenas, L., Carvallo-Munar, E. and Macassi-Jauregui, I. Combined model of SLP and TPM for the improvement of production efficiency in a MYPE of the Peruvian textile sector. P*roceedings of the 18th LACCEI International Multi-Conference for Engineering, Education, and Technology*, Virtual Edition, July, 27-31, 2020.

Mejia, S., and Rau, J., Analysis of improvement for the implementation of lean manufacturing tools in the clothing line of a textile company in Lima, *Proceedings of the 17th LACCEI International Multi-Conference for Engineering, Education, and Technology,* Jamaica, July, 24-26, 2019.

Parida, P., and Pradhan, K., Productivity and efficiency of labour intensive manufacturing industries in India: an empirical analysis, *International Journal of Development Issues*, vol. 15, no. 2, pp. 130-152, 2016.

Rodríguez, A. and Pérez, A., Métodos científicos de indagación y de construcción del conocimiento, *Revista Escuela de Administración de Negocios*, no. 82, 179-200, 2017.

Ruiz, S., Simón, A., Sotelo, F. and Raymundo, C., Optimized plant distribution and 5S model that allows SMEs to increase productivity in textiles. *Proceedings of the 17th LACCEI International Multi-Conference for Engineering, Education, and Technology*, Jamaica, July, 24-26, 2019.

Santa María, V., and Suarez, B., Estandarización De Procesos Operativos Y La Satisfacción Del Cliente De Una Empresa Del Sector Joyería. *Proceedings of the 19th LACCEI International Multi-Conference for Engineering, Education, and Technology*, Buenos Aires, July, 21-23, 2021.

Sarmiento, S., Nava, V., Carro, J., and Hernández, C., Estudio comparativo de los factores de innovación en la pequeña y mediana empresa de manufactura textil, *Contaduría y Administración*, vol. 63, no. 3, pp.1-24, 2017.

Sociedad Nacional de Industrias, Available: https://sni.org.pe/estudios-economicos/, Accessed on October 20, 2022

Stefanova-Stoyanova, V. and Danov, P., Comparative Analysis of Specialized Standards and Methods on Increasing the Effectiveness and Role of PDCA for Risk Control in Management Systems, *Proceedings of the 10th COMSCI International Scientific Conference on Computer Science,* Sofia, May 30 - June 2, 2022

Biographies

Renzo Sebastián Bernaola Vara student at the University of Lima studying the tenth cycle of the Industrial Engineering career, currently working in the area of project management at the same university. I practice soccer in my spare time and support my parents on weekends in their company. Currently, I am participating in a soccer championship at the university. I belonged to the student circle at the school during the 5 years of my school stage; as well as winning a science contest on aquarium plant seeds.

Raúl Alejandro García Ruiz student at the University of Lima studying the tenth cycle of the Industrial Engineering career, belonging to the Project Management circle at the same university, performing the role of project consultant and delegate of the Research Projects II course. Currently, working in the commercial and marketing field of retail companies and specializing in these areas through virtual and face-to-face courses.

Carlos Augusto Lizárraga Portugal Industrial Engineer from the University of Lima, Approved Title "Cum Laude". Master in Administration – ESAN; Doctor of Education, San Martín de Porres University. Post Degree in Auditing and Implementation of Integrated Management Systems (ISO9001 Quality, ISO 14001 Environment, OHSAS18001 Occupational Health and Safety, Social Responsibility). Business consultant specializing in Strategic Planning, Occupational Health and Safety Management Systems, Logistics Management, Purchasing Management, Strategic

Inventory Control – Supply Chain Management, Warehouse Management, State Purchasing Process, Costs and Asset Management. the production. Experience in sectors such as clothing, plastics, industrial footwear, fishing, services, marketing, training, etc. Professor at the University of Lima in the Industrial Engineering career, teaching courses on Comprehensive Security, Maintenance Management, Business Diagnosis and Research Projects. Trainer and facilitator in Seminars on Strategic Planning, Business Organization, Production Management, Operations Management, Strategic Inventory Control, Supply Chain Management, Industrial Safety and Comprehensive Safety Management. Thesis Advisor and Jury to opt for the Title of Industrial Engineer.