Production Increase of a Peruvian Sleepwear Manufacturer SME through SLP, TPM, Poka Yoke and Work Standardization

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Abstract

Currently, the Peruvian textile sector, especially the MSMEs and SMEs, is affected by several factors that have lowered its productivity. This industry is already dealing with complex markets for a high level of competitiveness and informality. For this reason, it is imperative to counteract these factors internally affecting the companies' operating processes. Most companies, intending to lower costs, seek to hire personnel with a certain level of experience since it is assumed that they would support them in carrying out the work in their position, meaning that the personnel hired are not trained to perform their tasks. Likewise, maintenance is minimized or non-existent, and plants are not adequately organized. All these factors result in a decreased level of productivity. This paper seeks to demonstrate that regular training, planned maintenance, and proper plant layout will reduce the negative effects mentioned above. For this purpose, there are specific tools available that will be mentioned in this article, such as SLP, Autonomous Maintenance and/or Planned Maintenance (TPM), Poka Yoke, and Standardized Work, as they will be implemented for intervention in the production process in a company aimed to manufacture sleepwear, where an increase of 14% in their productivity level was achieved.

Keywords
Standardized Work, SLP, TPM and Poka Yoke.

1. Introduction
When talking about the textile industry, it is essential to mention the clothing manufacturing industry since they are highly related, and there are studies indicating that around 50% is destined for the clothing industry, and the rest, for industrial and household products (Alvarado & Vieyra, 2002). This industry represents the most important source of income for developing countries; such is the case that in 2001, it accounted for 2.5% and 3.3% of world trade in merchandise and manufactured goods, respectively (Angulo, 2000). Currently, the value and quality of textile products have evolved positively. They have become very attractive for businessmen in the main markets of the world, such as China, the United States and Colombia (Rosales, 2019). In Peru, the raw material has been used to good advantage thanks to the diversity of the altitudinal floors and the expertise of local artisans (Proinversion, 2005). SMEs have a very important value because they are responsible for making a great contribution to increasing the employment rate and national production. However, due to the high level of informal and foreign competition, such as Chinese production with low labor and material costs, the challenge of remaining active and surviving in the market is a daily struggle, as it requires greater investment in technologies and new product design proposals (Morón and Serra, 2010).

The literature reviewed allowed to determine that MSMEs in Peru face different problems that directly affect and restrict their future development (Sauser, 2005). At the same time, it is the responsibility of these entities to develop short and medium-term strategies and skills; all this to be able to face and not decline before the different and difficult situations and scenarios that new entrepreneurs have to face (Barba et al. 2007). Such

Inefficiencies are related to human resource management, accounting, and financial aspects, marketing, pricing, production control, inventory control, ease of raising capital, restricted vision for the future, planning, and research (Avolio et al. 2011). For example, a textile company in Lima, Peru, had problems with delays in order delivery dates. This was because the inventory turnover time was very long, so much so that it represented 39% of the orders produced (Santivañez and Saroli, 2020). On the other hand, an investigation in Colombia pointed out that the financial measures taken had a purely short-term oriented perspective, which envisioned a problem since, over time it would become an unproductive company; and this was because they would be very exposed and unprotected against changes in the market (Ambuila, 2018). The foregoing suggests that textile manufacturers have developed based on inefficient, defective, and problematic processes. And that is why it is required the development of new proposals for solutions to this complex situation.

Because of this situation, the Peruvian textile sector needs to increase its efficiency level to respond to the market demand of the sector. To this end, a case study was selected to demonstrate the sector's setback concerning its deficient production capacity resulting from different failures in operational development. The failures identified are long unproductive times and a high rate of reworks, which result in economic damage since they represent 20.78% of the total annual cost concerning the case study. In this regard, and to solve the above-described problem, an improvement model was developed, in which SLP, TPM, Poka Yoke and Standardized Work tools were implemented; all under measurable and quantifiable indicators. This model was developed based on success cases found in the literature reviewed, which were similar in terms of the problems faced.

1.1 Objectives

The main objective of this paper is to demonstrate that, using industrial engineering tools, it is possible to improve the production process of a company dedicated to manufacturing sleepwear. Firstly, any relevant information for the case study will be identified. Secondly, Standardized Work and SLP methods will be applied to reduce cycle and route times. In addition, Poka Yoke and TPM methods will be used to decrease the percentage of defective products and in the number of electrical or sewing machine failures due to lack of maintenance.

2. Literature Review

2.1. Standardized work

Process standardization allows to reach optimum levels of quality and production; however, there are currently organizations where workers empirically perform their jobs, making the levels of the indicators not the desired ones (Velasquez and Fierro, 2020). Standardization is a process that must be developed through a work methodology and training of the personnel that will perform the work, indicating how the process will be developed, what training the person requires and what a good performance consists of (Harrington, 1992). By standardizing the work, it is possible to observe a reduction in the production line waste, in unnecessary movements, in stop frequency, an improvement in quality and an increase in finished products (Caldera, 2019).

2.2. Poka yoke

Poka Yoke is a Japanese term where Poka means “inadvertent error” and Yoke means “to prevent”; the purpose is to prevent a possible error in the production process or correct it without causing delays, and costs and delivery time increases (Fuchs, 2008). Even though there are designs, such as the automation of a production line, which are designed to prevent errors, this does not guarantee that human error will not occur; for that reason, Poka Yoke systems are used to ensure that the work performed by the operator is free of faults (Brownhill, 2005). In short, this system is mostly used by the manufacturing industry to increase quality indexes and discard errors caused by operators in the production line (González, 2009).

2.3. Systematic layout planning (SLP)

SLP was developed by Richard Muther in 1986 and was a guide for planning the plant layout (Muther, 1968). Although it was designed to be used in different areas, it was finally used mostly in the industrial field (Ortega, 2014). The Systematic Plant Layout Planning or SLP is a widely used resource as it allows to arrange in an organized way the workspaces and industrial equipment used. In turn, it provides the competent use of resources, optimization of the different processes involved, greater potential and continuous improvements (Potadar et al. 2018). This tool is not only based on quantitative studies regarding the extension of the plant under study, but it is also considered a qualitative study in which the relationship between work areas, circulation of materials, specific demand of the processes, storage requirements and ergonomics necessary for operators and/or labor are included (Torres, et al., 2020). Finally, it should be noted that, in terms of comparisons of tools of this type and for this type of challenge regarding plant layout, the SLP is the most accepted and used tool.

2.4. Total Production Maintenance (TPM)

TPM or Total Productive Maintenance is the result of the evolution of maintenance management systems. This means that the standard systems used many years ago have not been replaced, but have been integrated and improved, resulting in a more sophisticated system with favourable results. In other words, TPM emerges as an integration of the American preventive maintenance (PM) into the industrial environment of Japan, where this evolved maintenance system was born in the seventies (Cuatrecases and Torrell, 2010). According to the TPM approach, Autonomous Maintenance was included as an innovation that distinguishes it from the other previous maintenance concepts, where workers are responsible for their workspace and the industrial equipment they handle. They are in charge of maintaining order, cleanliness, proper operation and the identification of possible future problems that may cause problems in the operation of the equipment and therefore in the rest of the production process. By including this contribution to continuous maintenance (related to continuous improvement KAIZEM), it is possible to develop the concept of TPM (Ramakrishnan and Nallusamy, 2017).

3. Methods

For this work, the case study method or case study was selected as the type of research, which develops an article in detail about a specific topic. In this case, it is about a company belonging to the textile sector. For this study, qualitative methods but mainly quantitative methods have been used to carry it out.

According to the statements of one of the most important scholars on this type of research methodology, Yin (1989), this method would develop mostly experimental research, which analyses a contemporary situation and how it develops in its real environment, where the terms between the situation and the environment are not entirely defined or clear, and the roots of the data or evidence are diverse.

However, there are some authors who have questioned and undermined this type of research, such as Venkatraman and Grant (1986), Stoeker (1991), since they claim that it has a very low level of reliability and therefore a dubious validation, undermining its prestige.

Despite the foregoing, many other authors recognize the relevance and usefulness of the case study methodology, such as Martínez (2006), who state that it represents a valuable research tool since its greatest advantage is that the behavior of the people involved in the process is considered and recorded. According to Yacuzzi (2005), these types of research mostly assume an integrative intention. The case studies define their unit of analysis with a particular case, in the case of an individual study (Yin 1984) or a comparative study in the event of a confrontation between different cases. All these advantages help to define and analyze the problem from different perspectives (Dul, 2007).

There are three types of research design. This research uses the quasi-experimental design, which contrasts causal hypotheses. In both the experimental and quasi-experimental models, the intention is to determine the extent to which the proposed solution achieves the established objectives, and this is done by means of measurements of previously defined indicators. The difference between the two lies in the fact that, in the quasi-experimental type, the study group is not randomized in terms of both the conditions and the selection of participants. Thus, it begins with the definition of an object of study, on which comparisons will be made. The subject and the start and end conditions are selected at convenience, making sure that they are as similar as possible, to identify the results obtained once the solution, policy or program has been applied. Therefore, it can be affirmed that results were obtained if the comparison group or object succeeds in capturing such changes compared to the recipient object or group (White & Sabarwal, 2016). However, this methodology faces some challenges, such as its vulnerability to attacks on its inferential validity in contrast to the experimental methodology, or the fact that there is a greater likelihood of generalization of the results obtained to the research of different kinds. Despite this, and due to the fact that on many opportunities this methodology represents the only work option, its correct planning and execution may result in truthful information on the impact of the solution or treatment proposed and its development (Bono, 2012).

Similarly, to be consistent with the sense and development of the control group, in this article, a control group defined in a clothing workshop was selected before applying any proposed solution or, in other words, before making any change. In contrast, the comparison group would correspond to the same, with the distinction added to the period after the application of such changes. Regarding the collection of data necessary for the research, probabilistic methods were not applied since the investigation is oriented to the observed, defined, and measured causes. When determining the operative process of the case study, it was possible to distinguish the existence of many unproductive times and reworks in specific workstations, which result in high mean times and unrepresentative standard times, especially in the sewing area. There is a direct relationship between the overtime required to carry out some activities, the lack of standardization in some processes, and inadequate facilities or defective raw materials. In some cases, these deficiencies do not seem very noticeable or relevant at first glance, but they represent a major obstacle to productivity.

To define the current situation of the clothing workshop, a tree diagram was developed to determine the causes and consequences and therefore the productivity challenges of the SME.

The Clothing Workshop started as an improvised and illegal workshop, and with the passage of time, it is now a registered and formalized company. Despite that, at the beginning of its operations, it had a certain client portfolio and an operational process based on its own experience, which was sufficient to fulfill its orders and increase its sales, as its capacity allowed it. However, they have now increased their number of clients and therefore the number of orders. However, their operating process is still based on their experience-based model, which lacks essential factors such as the standardization of operations, maintenance, and order, which results in an inefficient operational capacity, reducing its growth capacity in the market and representing economic loss. Therefore, it is necessary to consider all the shortcomings and weaknesses in the process to correct and generate value.

According to the study of the problem tree developed in the diagnostic process, it was identified that the leading causes are constant breakdowns, poor electrical installations, lack of standardization in sewing methods, poor raw material quality, and, finally, defective sewing. From these causes, it was possible to define two problems, unproductive times and reworks, which directly result in low productivity, and finally represent a negative economic impact. According to Quintero (1991), it is necessary to establish standard times for the proper development of activities. However, to achieve this, all the causes mentioned above should, in theory, be corrected. That is because, in this case, to establish a standard time, all the conditions related to production should be stable so that there are no inconveniences in terms of design, setbacks, quality of raw material, delays, or reworks. There should also be a balance regarding the required efforts and an adequate production capacity; however, reality shows us that these conditions do not always exist, so it is necessary to consider other factors that can be named tolerances, i.e., unproductive times.

To conclude, by defining the main sources of problems in the case study, it will be possible to develop, detail, and establish solutions and the necessary tools to increase productivity. These solutions must be measurable to determine their effectiveness, which is carried out by deciding on indicators corresponding to each cause and, thus, to each solution. It is expected that, by implementing these tools, the production capacity will be increased, making the clothing workshop competitive in the corresponding sector. In other words, the downtime and unnecessary routes identified in the process that directly deteriorate the productivity of the entire operational process should be reduced by controlling the route time, the mean time between failures (MTBF), the mean time to repair (MTTR), maintenance audits, cycle time, and the percentage of defective products (Figure 1).

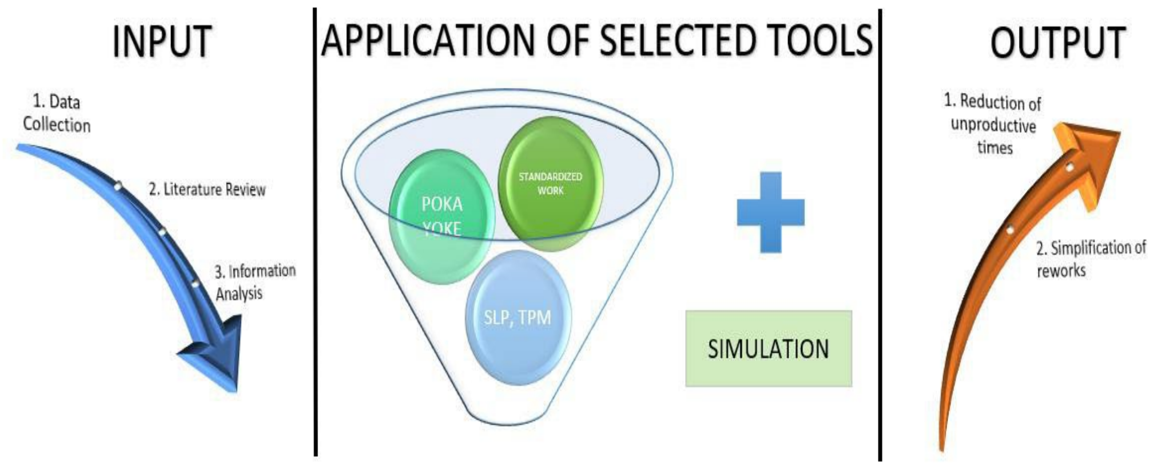

Figure 1. Contribution of tools in the proposed improvement

4. Data Collection

The data collection process consists of the search, collection, and measurement of the necessary information allowing a complete assessment of the case study. As regards this research, since it is textile manufacturing company, it is necessary to apply a method assessing the current or real situation of the company at the time the study thereon is developed, in order to compare it with its subsequent situation.

In relation to the case study, the recorded revenues corresponding to the production and sale of two-piece ladies' sleepwear sets, trousers and long sleeves, with round neck and Pima cotton do not correspond to the range of corresponding and related values in the same sector and under similar conditions in terms of the number of operators and quantity of equipment or machinery. This situation evidences the need to develop an analysis of the entire production process. For this purpose, simulation will be used since, through this method, the stages of the process will be defined in an overview and each related workstation will be established; especially those workspaces tasks which depend on the operator's manual skill, whether or not the operator uses some type of machinery, such as the stages of laying, tracing, cutting, printing, sewing, and enabling. These workstations require operators since it is their responsibility to operate the machines to carry out the tasks, using their experience and training. Due to the aforementioned, delays are generated, but also due to different factors, such as machine breakdowns, lack of workers' training or experience, defective spare parts or supplies, and poor electrical installations. The data obtained corresponds to real measurements, which were collected on different working days within the case study. This sample was taken in six and a half weeks during the work shift of 8-hours a day in each service workspace pertaining to the productive circuit (Figure 2).

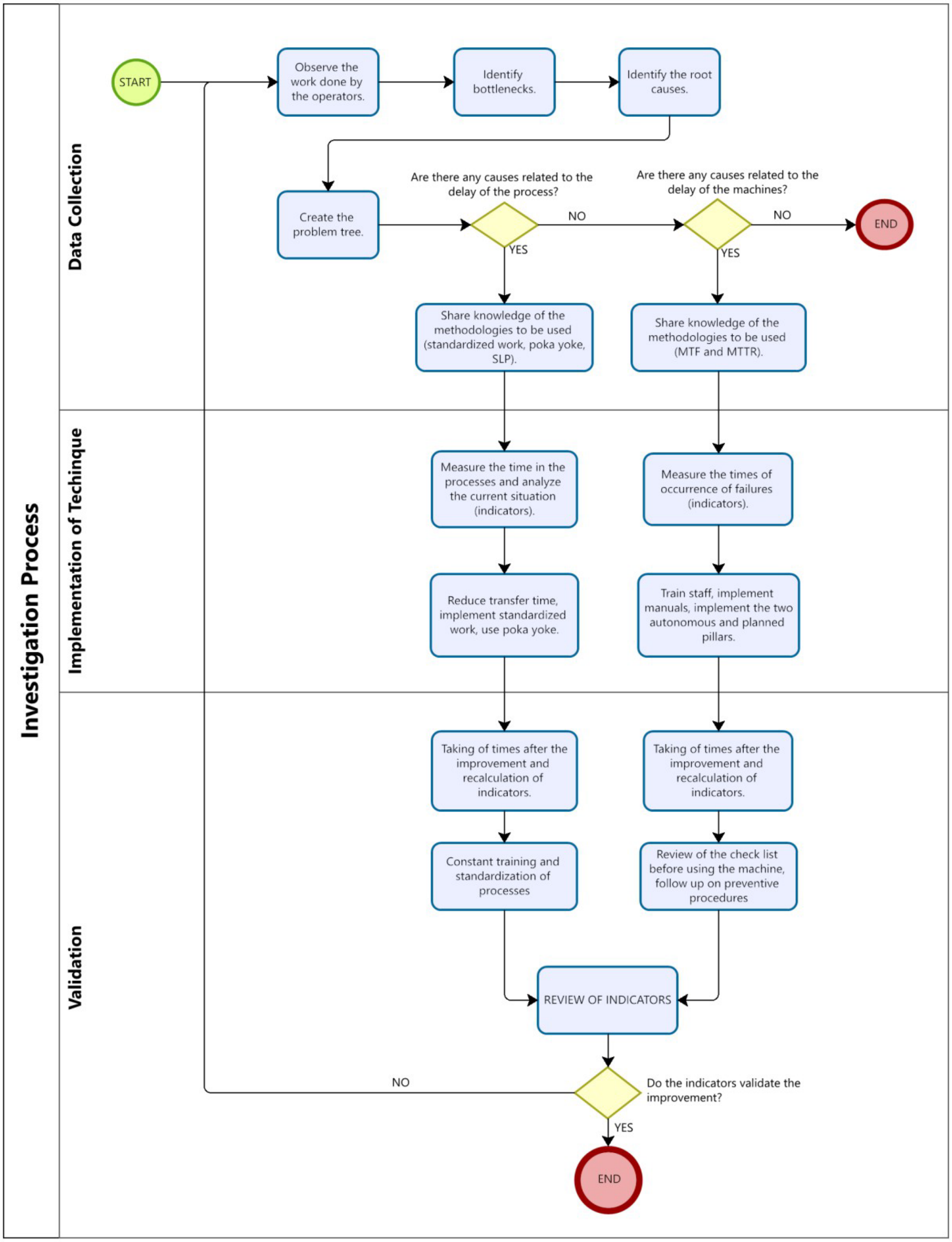

Figure 2. Investigation process

5. Results and Discussion

5.1 Numerical Results

The results are presented in this section, considering the case study's main problem that, in this case, is related to a lower than desired productivity level, since purchase orders must be rejected because they exceed the current production capacity. For the first section, the analysis of the initial situation of the case study is considered. Once the previously mentioned data collection process has been carried out based on the definition of the indicators, they are calculated. For instance, the route time between processes was quantified, from which an average value of 217.6 minutes was obtained for the current situation of the company, applied in a monthly period. It is observed that it is a high amount and that, consequently, the time of unnecessary routes is increased. In this regard, the MTBF (Mean Time Between Failures) and the MTTR (Mean Time to Repair), are the two key indicators to define the number of machine stoppages either due to electrical failures or due to lack of maintenance. With respect to these indicators, the MTBF of 80 hours and the MTTR of 3 hours represent machines and operators at a full stop. Considering these quantities, an extended period of downtime is evident, which means an economic deficit from the point of view of units not produced and from the perspective of time not worked but paid. In addition, the percentage of defective products was considered one of the indicators as they represent a cost and a lost production opportunity for the case study. Numerically the percentage of defective products for the sewing process corresponds to 10% for t- shirts and 5% for trousers. Finally, the cycle time is a very important indicator since it will allow to know how long it takes to place an order and how this time affects the production process. Currently, this value is 119.15 hours on average per order attended. Along the same line, the effect of the necessary tools is analysed to provide a solution to these problems. The constant training in methods to achieve a standard-oriented process with fewer defective products reduces the cycle time by 6%, and the number of defective products to 3%. In the same way, coordinated maintenance increased the MTBF to 185 hours and decreased the MTTR to 1 hour. Finally, the workstation reorganisation decreased the cycle time by 6% which directly influences the indicator of total amount of pyjamas and which intervenes directly in terms of productivity and therefore its response capacity.

5.2 Proposed Improvements

As shown in Figure 3, an analysis of the activities involved in the production process was performed using the activity relation diagram. One necessary process and three essential processes were identified. Additionally, the results show that the operations are not properly located and must be modified. As shown in Figure 4, the processes were organised in such a way that the flow of raw materials is continuous, avoiding unnecessary transfers.

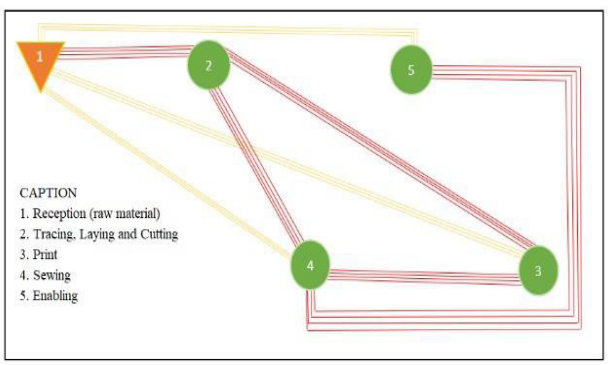

Figure 3. Relational diagram of activities (Before)

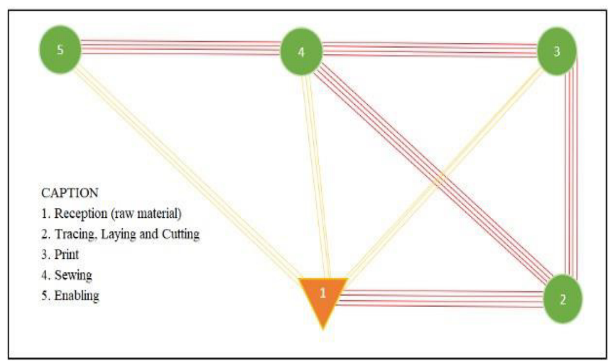

Figure 4. Relational diagram of activities (After)

In Table 1, in order to study the times of the case, time samples were taken at the different workstations over a period of 2 months, using the direct observation method.
The participants involved were the operators who carry out their work in these same areas. It is important to highlight that certain delays were considered due to the nature of the work developed.

Table 1. Times taken by observation

DAY	Request for material	Traced	Laying	Cutting	Print	Sewing	Enable
1	65,36	1,08	1,56	6,09	23,47	124,26	23,46
2	61,25	1,03	1,52	6,04	23,37	124,22	23,42
3	62,34	1,04	1,53	6,05	23,35	124,23	23,43
4	60,83	0,96	1,47	5,96	23,42	124,17	23,37
5	69,24	1,03	1,52	6,03	23,35	124,22	23,42
6	65,93	1,07	1,56	6,09	23,42	124,26	23,46
7	69,86	1,02	1,51	6,02	23,36	124,22	23,41
8	69,23	0,99	1,49	5,99	23,49	124,19	23,39
9	61,86	1,02	1,52	6,03	23,37	124,22	23,42
10	62,89	1,02	1,51	6,02	23,35	124,21	23,41
11	63,79	1,07	1,55	6,08	23,38	124,25	23,45
12	68,88	1,05	1,53	6,06	23,35	124,23	23,43
13	63,73	0,93	1,45	5,92	23,44	124,15	23,35
14	69,47	0,92	1,44	5,90	23,38	124,14	23,34
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
60	65,38	1,01	1,51	6,02	23,38	124,21	23,41
AVERAGE	64,91	0,99	1,50	5,99	23,40	124,18	23,40

The Figure 5 corresponds to a graph that allows us to compare the current situation of the case study to the version with the improvements applied. To this end, this graph is supported by 5 key and measurable factors that will allow quantifying how effective the measures taken were. With regard to the stops due to electrical and machine failures, a significant reduction is observed. However, an increase in the number of pyjamas produced can be visualised. It is important to highlight that these variations favour an increase in the responsiveness of the production process.

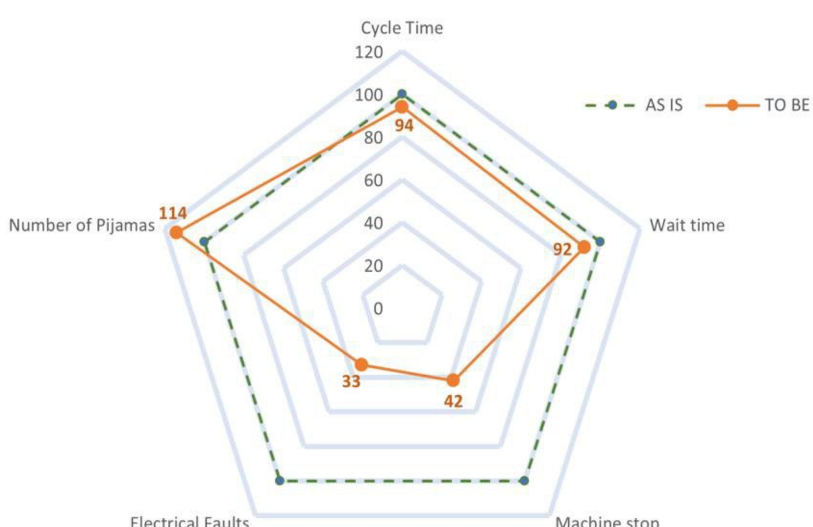

Figure 5. Assessment

5.4 Validation

In order to obtain more reliable results, the Arena software will be used. When using this validation tool, all processes related to the production area will be included. Moreover, before starting the said simulation, it is necessary to define the necessary distributions for the processes. For this reason, the Input Analyzer software will be used. In order to achieve a reliable sample, 200 observations were made including all resources such as raw materials, machines, operators, operation times, as well as failure times, and reworks. In addition, a confidence level of 95% and an error of 5% are applied, which makes the subsequent comparative analysis reliable. Figure 6 shows the proposed model with the processes described above.

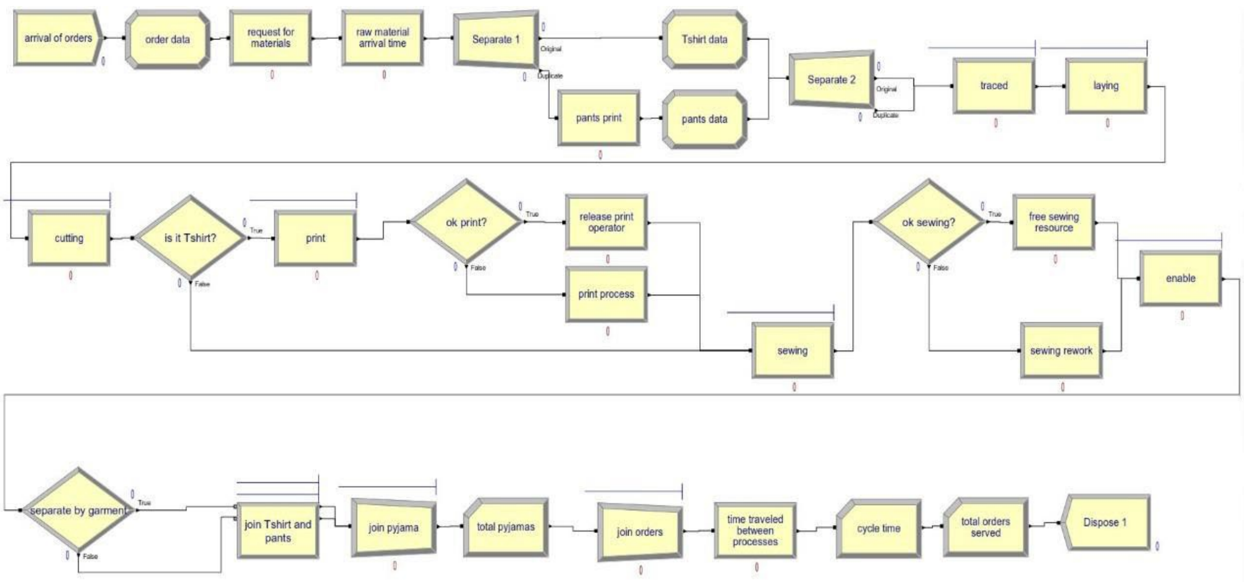

Figure 6. The proposed model simulated

The Figure 7 shows the results in the AS – IS and TO BE scenarios where a decrease in cycle time and greater fulfilment of requested orders are observed. As in Figure 8, the stops due to electrical failures and poor machinery maintenance decreased, which corroborates the increase in the production responsiveness to new orders.

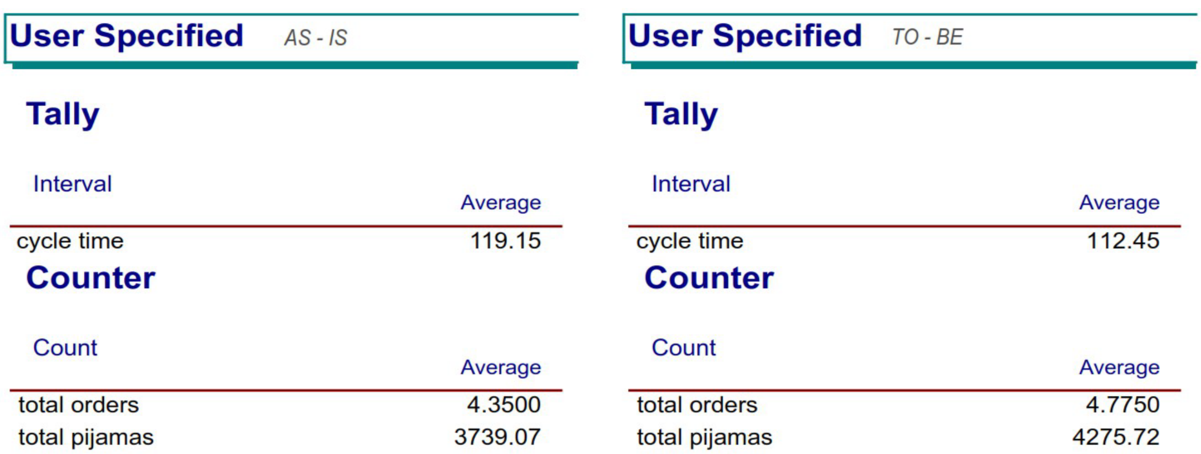

Figure 7. Simulation results

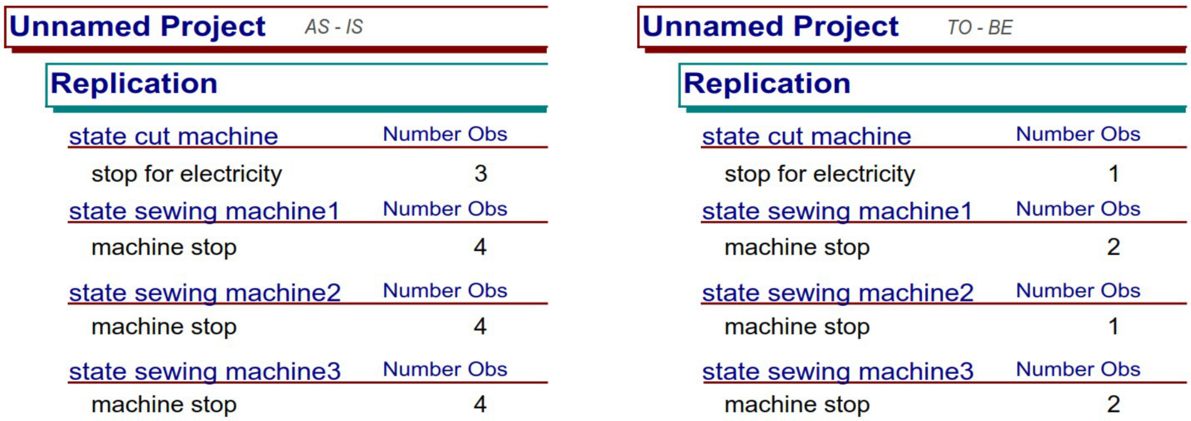

Figure 8. Simulation results

6. Conclusion

Table 2 shows the most importants indicators. The increase in these indicators means a negative effect on productivity. However, it can be seen that they were reduced after the improvement was made, making a positive impact. Likewise, in Table 3, we can observe a significant reduction in cost and an increased in the units produced. In conclusion, the study carried out on the Peruvian sleepwear manufacturing SME achieved the established objective of this paper, which is to improve the company's production process using the described engineering tools. Thanks to standardized work, cycle times in production are reduced. As for the Poka Yoke, by preventing errors in the processes, the percentage of defective products is reduced. With respect to the SLP, it was possible to reduce the total route time; finally, with the results of the TPM, it was decided to train the operators regarding the management of the autonomous and planned maintenance of the machines used in the production line.

Table 2. Indicator Comparison

INDICATORS	AS IS	TO BE	RESULTS
CYCLE TIME (min)	119.15	112.45	6% ↓
WAITING TIME (min)	89.01	82.29	8% ↓
MACHINE STOP (min)	12	5	58% ↓
STOP FOR ELECTRICITY (min)	3	1	67% ↓
TOTAL PYJAMAS (unit)	3740	4276	14% ↑

Table 3. Reduction Cost

AS -IS					TO - BE					REDUCTION COST
TOTAL UNITS 3740					TOTAL UNITS 4276					
ACTIVITY	UNITS	FAILURE	UNIT COST	TOTAL COST	ACTIVITY	UNITS	FAILURE	UNIT COST	TOTAL COST	
PRINT	3740	261.8	S/ 1.65	S/ 431.97	PRINT	4276	128.28	S/ 1.65	S/ 211.66	49.00%
SEWING TSHIRT	3740	374	S/ 1.70	S/ 635.80	SEWING TSHIRT	4276	128.28	S/ 1.70	S/ 218.08	34.30%
SEWING PANTS	3740	187	S/ 1.10	S/ 205.70	SEWING PANTS	4276	128.28	S/ 1.10	S/ 141.11	68.60%

References

Ambuila, I, Sistema de Indicadores de gestión aplicado a las áreas comercial, calidad y producción de la empresa Confecciones A&J SAS, Disponible: https://red.uao.edu.co/bitstream/handle/10614/10414/T08041.pdf;jsessionid=8BD69187BD5225DC390B04A6FF117088?sequence=5, 15 de julio de 2022.

Angulo-Luna, M, Análisis del cluster textil en el Perú, Disponible: https://sisbib.unmsm.edu.pe/bibvirtualdata/Tesis/Ingenie/angulo_lm/cap2.PDF, 03 de Agosto de 2022

Arroyo López, M, and Cárcamo, M, La evolución histórica e importancia económica del sector textil y del vestido en México. Economía y Sociedad, XIV, Disponible: https://www.redalyc.org/articulo.oa?id=51015546004, 13 de septiembre de 2022

Avolio, B, Mesones, A, and Roca, E. Factores que limitan el crecimiento de las micro y pequeñas empresas en el Perú (MYPES), Disponible: https://revistas.pucp.edu.pe/index.php/strategia/article/view/4126, 09 de julio de 2022

Barba-Sánchez, V, Jiménez-Sarzo, A., and Martínez-Ruiz, M, Efectos de la motivación y de la experiencia del empresario emprendedor en el crecimiento de la empresa de reciente creación, Disponible: https://www.academia.edu/23052496/Efectos_de_la_motivacion_y_de_la_experiencia_del_empresario_emprendedor_en_el_crecimiento_de_la_empresa_de_reciente_creaci%C3%B3n, 21 de Agosto del 2022

Bono, R. Diseños Cuasi-experimentales y longitudinales. Universidad de Barcelona. http://diposit.ub.edu/dspace/bitstream/2445/30783/1/D.%20cuasi%20y%20longitudinales.pdf, 7 de agosto de 2022

Brownhill, M, Beyond Poka yoke. Fabricating & metalworking, Dispomible: https://www.proquest.com/, 26 de agosto de 2022

Caldera, H. *Evaluating the enablers and barriers for successful implementation of sustainable business practice in 'lean' SMEs. Journal of Cleaner Production*, Disponible: https://www.sciencedirect.com/science/article/abs/pii/S0959652619302586, 04 de septiembre de 2022.

Info Alpacas, tomado de Perfil de Mercado y Competitividad Exportadora de Prendas de Alpaca. por MAXIMIXE. Disponible: http://infoalpacas.com.pe/wpcontent/uploads/2013/04/Tejido_Prendas_de_Alpaca.pdf, 22 de septiembre de 2022

Dul, J, and Hak, T. Case Study Methodology in Business Research (1st ed.). Disponible: https://doi.org/10.4324/9780080552194, 07 de septiembre de 2022.

Fuchs, J. ¿What is Poka Yoke and how will it help your bottom line? US Fed. News service, Disponible: https://www.proquest.com/, 20 de agosto de 2022

GONZÁLEZ, S, POKA YOKE, Concepto de Poka Yoke. Disponible: http://www.elprisma.com/apuntes/ingenieria_industrial/pokayoke/default.asp, 13 de junio de 2022

HARRINGTON, J, Mejoramiento de los procesos de la empresa, Disponible: https://www.proinnovate.gob.pe/fincyt/doc/INFORMES_CIES/Textil%20y%20confecciones%20final.pdf, 26 de agosto 2022.

Martínez, P, El método de estudio de caso: estrategia metodológica de la investigación científica. Revista Pensamiento & Gestión, núm. 20, julio, 2006, pp. 165-193 Universidad del Norte Barranquilla, https://www.redalyc.org/pdf/646/64602005.pdf, 20 de julio de 2022.

Morón, E y Serra, C. TECNOLOGIA E INNOVACION: SECTOR EXPORTADOR TEXTIL Y CONFECCIONES PERUANO. Disponible https://www.proinnovate.gob.pe/fincyt/doc/INFORMES_CIES/Textil%20y%20confecciones%20final.pdf, 25 de agosto de 2021.

Proinversión, Guía de Inversiones en el Sector Textil y de Confecciones para la exportación, Tema: Tiempo Estándar. Escuela de Administración de Negocios Universidad de Costa Rica. https://www.academia.edu/26424661/TEMA_TIEMPOS_ESTANDAR, 12 de septiembre de 2022

Ramos, C, *Designing a plan based preventive maintenance to improve reliability in machine availability and circular in textile company wg. Sac – lima*, Disponible: www.revistasucv.edu.pe, 30 de juliol del 2022

Rosales, S, Exportadores textiles peruanos apuestan por mayor valor agregados, Disponible: https://gestion.pe/economia/exportadoras-textiles-peruanas-apuestan-mayor-agregado-255835-noticia/?ref=gesr, 18 de julio de 2022.

Santivañez, M., and Saroli, L, Modelo de manufactura esbelta adaptada a la reducción de tiempo de entrega de pedidos en una Pyme peruana del sector textil-confección, Disponible: https://repositorioacademico.upc.edu.pe/bitstream/handle/10757/651892/Santiva%c3%b1ez_EM.pdf?sequence=3&isAllowed=y, 29 de agosto de 2022.

Sauser, W, Ethics in Business: Answering the Call. Journal of Business Ethics, Disponible:

http://www.jstor.org/stable/25123527, 04 de septiembre de 2022.
Suliman, S, and Husain Jawad, S, *Optimization of preventive maintenance schedule and production lot size. International Journal of Production Economics*, Disponible: https://www.sciencedirect.com/science/article/abs/pii/S0925527312000072 , 28 de agosto de 2022
Velásquez, J, Fierro, M. and Chávez, J. Estandarización del proceso de confección, a través de la ingeniería de métodos, para aumentar la productividad, en una empresa del ramo textil en el estado de Puebla. Instituto Tecnológico Superior de San Martín Texmelucan, México. Disponible: https://www.ecorfan.org/republicofperu/research_journals/Revista_de_Ingenieria_Industrial/vol4num13/Revista_de_Ingenieria_Industrial_V4_N13_1.pdf , 30 de julio de 20022.
Venkatraman, N, and Grant, J, Construct measurement in organizational strategy research: a critique and proposal, Academy of management review, Disponible https://journals.aom.org/doi/10.5465/amr.1986.4282628, 22 de julio de 2022.
White, H, and Sabarwal, S, Diseño y métodos cuasiexperimentales , Methodological Briefs, Disponible: https://www.unicef-irc.org/publications/817-dise%C3%B1o-y-m%C3%A9todos-cuasiexperimentales.html, 13 de agosto de 2022
Yacuzzi, E, El estudio de caso como metodología de investigación: Teoría, mecanismos causales,Validación, Disponible: https://ucema.edu.ar/publicaciones/download/documentos/296.pdf, 24 de agosto del 2022
Yin, R, Case study research: design and methods, applied social research methods series, Newbury Park Sage Disponible: https://panel.inkuba.com/sites/2/archivos/YIN%20ROBERT%20.pdf, 03 de agosto del 2022.

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