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Original Article

Productivity Enhancement through a Proposed Methodology in the Cutting Process of SMEs

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Abstract *- The textile industry is still an essential sector in the global economy, and Peru, it plays a significant role in job creation. However, it often faces challenges such as a lack of innovation, high competition that decides imported products, and low productivity. To effectively address this problem and improve competitiveness in the market, implementing the Lean Manufacturing tools just like that 5S, standardized work, and Kaizen es proposed. These tools focus on addressing the high cycle times in the production process and have proven to be effective in improving the efficiency and productivity of textile companies. Specifically, the research focused on the cutting process of the representative product, the dress, and the results showed a significant improvement in production, increasing from 26 to 33 garments per Man-Hour(M-H). In conclusion, implementing Lean Manufacturing tools can improve the productivity and competitiveness of the textile companies in Peru, and their implementation es recommended to address the challenges and opportunities of the sector.*

Keywords *- Productivity, Textile industry, Lean manufacturing, Cutting process, 5S, Kaizen, Standardized work.*

1. Introduction

At a global level, Micro and Small Enterprises (MSEs) and Small and Medium Enterprises (SMEs) play a fundamental role in the economic development of Latin America. According to a study by [1], these companies represent approximately 99% of the total; however, their contribution to GDP is limited. In the Peruvian context, the annual report revealed [2] that SMEs constitute 96% of the companies in the country. It is worrisome that 76.1% of them need an account registry, and the average educational level of the workers needs to be completed in high school, which can significantly affect decision-making and the implementation of new techniques. This same study mentions that China represents 23% of world production, while Peru is in position 24, with barely 1% participation.

According to [3] the textile and clothing sector in Pe generates around 400,000 jobs per year, representing 26.2% of the population employed in the manufacturing industry. However, during 2020, the sector's production experienced a 32.1% decrease due to the international crisis and the vulnerability of SMEs, which have an average permanence of 8 years in the market. Despite the significant contribution of the textile and clothing sector to the manufacturing GDP in the country, with 6.3%, it is worrisome to observe that productivity in micro-enterprises is 22.4% and in small companies 23%. These data highlight that [4] urgently needs to improve business management, promote training, and adopt new tools and technologies to satisfy the urgent need for the competitiveness of Peruvian companies in the sector and reduce the gap. The problem identified in the textile sector has been addressed by various authors, who have proposed different approaches and solutions to improve the efficiency and productivity of companies. In a case study of a Microenterprise dedicated to manufacturing clothing, it was found that the machines' unproductive times and unexpected stops were the main obstacles to efficient production. Implementing a combined model of SLP and TPM increased production efficiency by 5% [5].

Another case study in a textile business showed that the absence of process standardization lengthened lead times. Production needs ongoing rework. This result highlights the value of creating transparent, standardized processes to boost productivity and reduce production mistakes [6]. Brazilian textile businesses have adopted new, simple technology as part of their plan to compete with cheap Chinese goods. They are now more competitive and able to remain in the market because of these new technologies [7]. According to an article about a textile business in the Lima area of Peru, the primary obstacles to be overcome were the lengthy sewing process and the company's poor production efficiency. The research aimed to increase shirt output via process improvement and optimization approaches [8]. These illustrations show the various strategies and fixes to solve poor efficiency in the textile industry. Each business may customize the best tactics by considering resource accessibility, technological aptitude, and the precise development goal.

It is critical to address poor efficiency in the context of SMEs engaged in the apparel manufacturing industry to decrease losses and boost productivity. The concerns discovered in this case study, such as wasted time, excessive waste, and rework, were chosen as a typical case study of the industry in order to solve this issue. An improvement strategy incorporating the 5S technique, Kaizen, and Standard Work was offered to solve these issues. These tools have proven highly effective in improving productivity and process management in the textile industry. It is essential to highlight that this research offers a unique combination of these tools adapted to the Peruvian textile environment.

2. Literature Review

2.1. Lean Manufacturing

Lean Manufacturing helps to optimize costs in the work system without implying any costs or efforts by reducing the time they do not add value. It groups techniques that develop a production system based on demand with minimum cost, high quality, and flexibility. The lean approach has five principles: value, stream mapping, flow, extraction, and continuous improvement. Studies validate that implementing the Lean philosophy in organizations improves delivery times, productivity, operational efficiency, reduction of defects, and increased customer satisfaction [9].

Some examples are one-piece flow methods, the 5S system, standardized work, and kaizen tools. The applications led to a reduction in manufacturing process times and the number of quality flaws. A decrease in total labour of 29% was seen after a year [10].

2.2. 5S

The 5S of Japanese origin represent the name of five actions: separate, in which only what is necessary to carry out the tasks must be kept; order, in which tools and equipment must be kept in conditions of easy use; clean, in which workplaces such as tools and equipment must be kept clean; standardize, in which the achievements obtained must be maintained and improved; and self-discipline, which must be put in place to comply with the established norms. In a good work environment, group learning can be applied in groups. [11]

In most cases where lean 5S has been applied, its application has been practical, achieving greater efficiency in those companies that have followed the application guidelines because both the work team and the administrative area have had a significant commitment between Yeah. A case presented is an implementation of 5S in a plastic bag manufacturing company in which it was achieved that the total operating time was reduced by 8% for blowing and 18% for printing. [12].

2.3. Standardized Work

Authors agree that a methodology must be followed to reduce situations, such as variability in manufacturing processes, by applying the standardized work tool. According to the authors, to carry out standardized work, five steps need to be carried out: 1) Carry out a diagnosis in which one must understand how the company works; 2) Action plan; once the processes have been analyzed, it seeks to identify the best practices or most efficient methods to carry out each task that implies the search for opportunities for improvement; 3) Table of standard actions, which consists of documenting the specific methods and steps that are considered the ideal standards to carry out each task; 4) evaluation, in which, once trained, they must be provided with the tools and resources so that the established standards can be understood and followed and 5) continuous improvement; since it is a fundamental aspect of standardized work where it is possible to keep up to date with changes in the environment [13].

Implementing a waste reduction strategy in a textile SME employing standardized work by integrating the work, processes, and equipment to cut the cycle time in half and, consequently, waste like faulty goods that cost the firm money. A 32 percent increase in delivery times and an 8 percent decrease in the failure rate were the outcomes of the deployment and validation using process simulation. [6]

2.4. Kaizen

The Kaizen method covers the integration and participation using the contributions and ideas of the employees to achieve the objectives. Continuously improve organizational processes. This implementation will enhance operational efficiency and, therefore, create a corporate culture that will guarantee the continuity of the contributions through the participation of the personnel in search of new and better solutions for the processes. The results show that Kaizen has had a significant impact on all functional areas of the company since it does not require substantial financial investments or new technologies and relies on the skills and creativity of the staff to achieve greater efficiency. Additionally, studies have shown that using Kaizen helps organizations reduce resource consumption and improve environmental performance. [14].

A case presented is that of a project that sought to improve the performance of an SME in the cutlery sector through lean tools such as Kaizen, in which production time was reduced by 27.6% and productivity increased by 36.5%. %. [15]

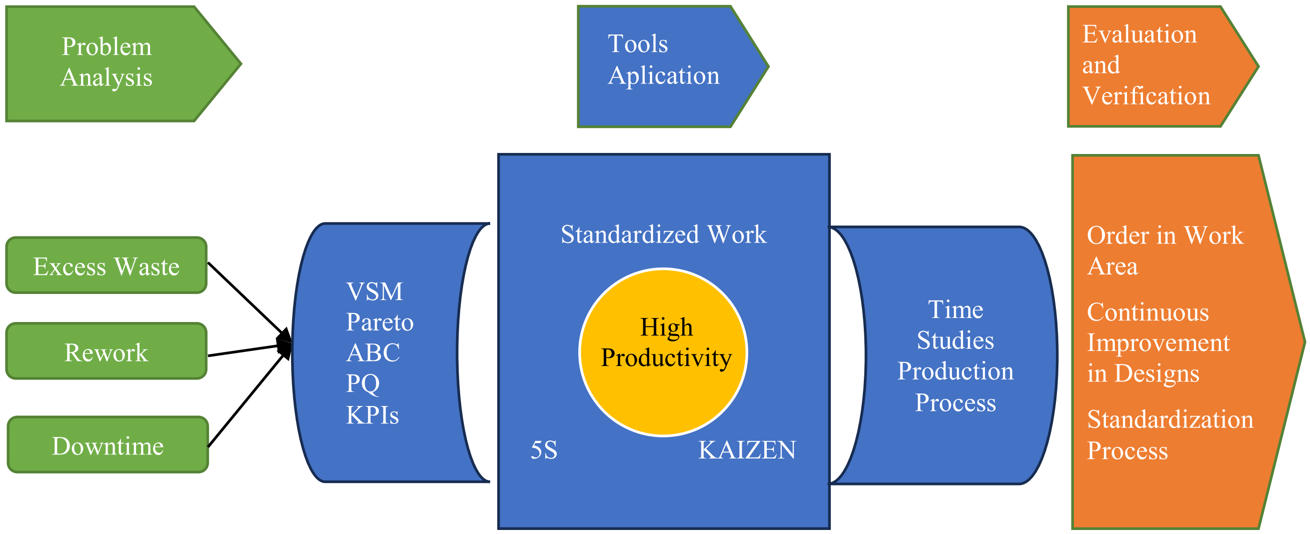

Fig. 1 Design of the proposed model adapted from [6], [11], [15], [32]

3. Method

3.1. Rationale for the Model

Even though Lean tools such as 5S, Kaizen, and standard work have been widely used in various industrial sectors, their specific application in the cutting area of textile companies has been the subject of limited research. This research seeks to fill that gap and provide a relevant approach to address operational challenges in the cutting area of textile companies. The suggested approach consists of three primary stages: initial diagnosis, tool implementation, and final assessment. It is based on the Lean manufacturing technique as described by many authors [10], [16], [17], [18], [19], and [20].

The existing condition is thoroughly analyzed during the first diagnostic using techniques like the ABC and PQ diagram and Value Streaming Mapping (VSM). This enables the identification of essential areas that need development. During the implementation phase, the cutting area is optimized for order, increased productivity, and continual improvement using 5S, Kaizen, and standard work gear. These instruments are used methodically and specifically to meet the firm's demands. In the final evaluation phase, an exhaustive analysis is carried out to measure the impact of the improvements implemented. Key indicators are used to compare the results before and after the implementation, which makes it possible to quantify the changes obtained in terms of efficiency and productivity. Figure 1 shows the model proposed.

3.2. Proposed Models

According to the analysis carried out in the investigation, it was identified that low productivity in the cutting process is the main problem that affects the company. It was found that the company produces 23 garments per MH, below the industry average, which is 48 garments per MH, according to the literature review. Once the main problem was identified, the three leading causes were determined: excess waste with an impact of 63.85%, reprocessing with an impact of 21.28%, and unproductive times with an impact of 14.87%.

These causes generated more specific root causes for each issue, including lack of continual review and improvement in pattern design, lack of a process for part inspection and review, and clutter in workspaces. In the design of the proposed model, the initial diagnosis was taken into account, and the most appropriate tools were selected to address the identified problems. It is important to note that tools such as Kaizen are new in the cutting area of Peruvian textile companies. The model is divided into three phases:

3.2.1. Analysis of the Problem

A thorough problem analysis is conducted, collecting relevant data and making detailed observations. Tools like Value Streaming Mapping (VSM) map the process's value stream and identify improvement areas. In addition, a root cause analysis is performed to understand the underlying causes of the identified problems.

3.2.2. Application

In this phase, selected Lean tools are implemented to address the identified issues. The tools used are:

5S

Focuses on the organization and cleanliness of the work area, improving productivity and reducing downtime.

Standardized Work

Clear standards are established for inspecting and reviewing parts, improving quality and reducing errors or defects.

Kaizen

Employee participation is encouraged to identify opportunities for improvement and make incremental changes in pattern design, optimizing the cutting process and reducing waste.

3.2.3. Evaluation and Verification

In this phase, a thorough evaluation is carried out to measure the impact of the implemented improvements. Key Performance Indicators (KPIs) compare results before and after implementation. This makes it possible to quantify the changes obtained and verify compliance with the established objectives.

3.3. Indicators

Table 1 shows the indicators of the proposed model.

- Indicator 1. Labour productivity
  This indicator represents the productivity according to the units of garments produced with the man-hours used.

$$\text{productivity} = \frac{\text{Units produced}}{\text{Man} - \text{Hours Employed}}$$

- Indicator 2. Efficiency
  It represents the efficiency of the whole process.

$$\text{Efficiency} = \frac{\text{Units produced}}{\text{Units Desired}}$$

- Indicator 3. Cycle time
  Represents the amount of time required to complete the steps in a standardized job

$$\text{Cycle time} = \frac{\text{(Production time available per day)}}{\text{(Units required per day)}}$$

- Indicator 4. Chalk area time
  It represents the time that the manual machine takes to make the marking of a production batch.
- Indicator 5. Tool search time
  It represents the time to search for the necessary tools to start the chalking and cutting.

4. Results

4.1. Description of the Scenario

This section presents the proposed model and the activities carried out during the implementation, including the simulation and the pilot. The objective is to demonstrate the effectiveness of each tool used, addressing the identified root causes.

First, the 5S tool was validated through a pilot plan and the collection of photographic evidence that reflected the current situation of the work area. On the other hand, the Kaizen tool was validated through simulation, where an automated machine was implemented to reduce waste and improve chalking times—finally, the standardized work tool optimized work processes and increased production efficiency.

Table 1. Indicators proposed

Reference	Indicator	Description
[21], [22], [23], [24]	Productivity	It refers to the number of units of a product generated about the time invested by the workers.
[25], [26]	Efficiency	Efficiency measures how inputs are utilized to produce desired outcomes and constitute the cornerstone of manufacturing industries in the market.
[27], [29], [31]	Cycle Time	The cycle time refers to the total time it takes to complete a specific task or process from start to finish.

Table 2. ABC analysis

	Amount (Units)	Sales (Pen)
Dress	1219	152,376
Blouse	239	8,353
Jumpsuit	77	9,493
Pants	72	6,584
Blazer	20	2,168
Coat	20	3,432
Skirt	15	1,240
Shorts	14	1,040
Jean	3	150
Total	1679	184,836

Table 3. PQ analysis

Guy	Sales (Pen)	Accumulated (Pen)	% Accumulated	Zone	%
Dress	152,376.00	152,376.00	82.44%	B	92.09%
jumpsuit	9,493.00	161,869.00	87.57%	B	
Pants	8,353.00	170,222.00	92.09%	B	
Blouse	6,584.00	176,806.00	95.66%	C	7.91%
Coat	3,432.00	180,238.00	97.51%	C	
Blazer	2,168.00	182,406.00	98.69%	C	
Skirt	1,240.00	183,646.00	99.36%	C	
Shorts	1,040.00	184,686.00	99.92%	C	
Jean	150.00	184,836.00	100.00%	C	

Table 4. Specifications for the cutting process

COMPANY: Case Study			SHEET:			
BRAND: Nancy's			MODEL: 0135			
LINE: Dress			SEASON: Spring			
DESCRIPTION AND CHARACTERISTICS: **BASE FABRIC**						
Batch:	1					mts. net
Composition:	Satin					500
Broad:	1.60					
Chalk length:	1.50					
BASE FABRIC COLOR CHART						
Colour name:	Last night	Black	V. Parrot	Prose	fuxia	Beige
Tolerance	+ / - 0.5cm		Clean cuts without deviations		Inspection after each cut	
TOTALS BY COLOR AND BY SIZE						
TOTAL GARMENTS TO BE PRODUCED: 350						

4.2. Initial Diagnosis

The company has identified a low productivity rate due to unproductive times, excess scrap, and rework costs. ABC analysis and PQ analysis were performed to focus the study, which revealed that dresses are the main product to be investigated in this case. This analysis is shown in Tables 2 and 3, respectively. Based on the study carried out on the garment production process, it was observed that productivity reaches a value of 26 garments per man-hour (mh), while the industry average is 48 garments per mh.

4.3. Design and Results

To address the problem of low productivity in the cutting area, a pilot plan was carried out to validate the implementation of the 5S methodology. This area was identified as critical due to the existing disorder, which caused lost time searching for tools and materials.

The first stage of the pilot plan consisted of identifying and eliminating unnecessary elements in the cutting area. A comprehensive review process specified and segregated equipment, tools, and materials infrequently used or in poor condition.

This made it possible to optimize the workspace and reduce the time needed to find the necessary elements in the cutting process. Figure 2 shows the implementation of the 5S pilot.

Fig. 2 5S implementation

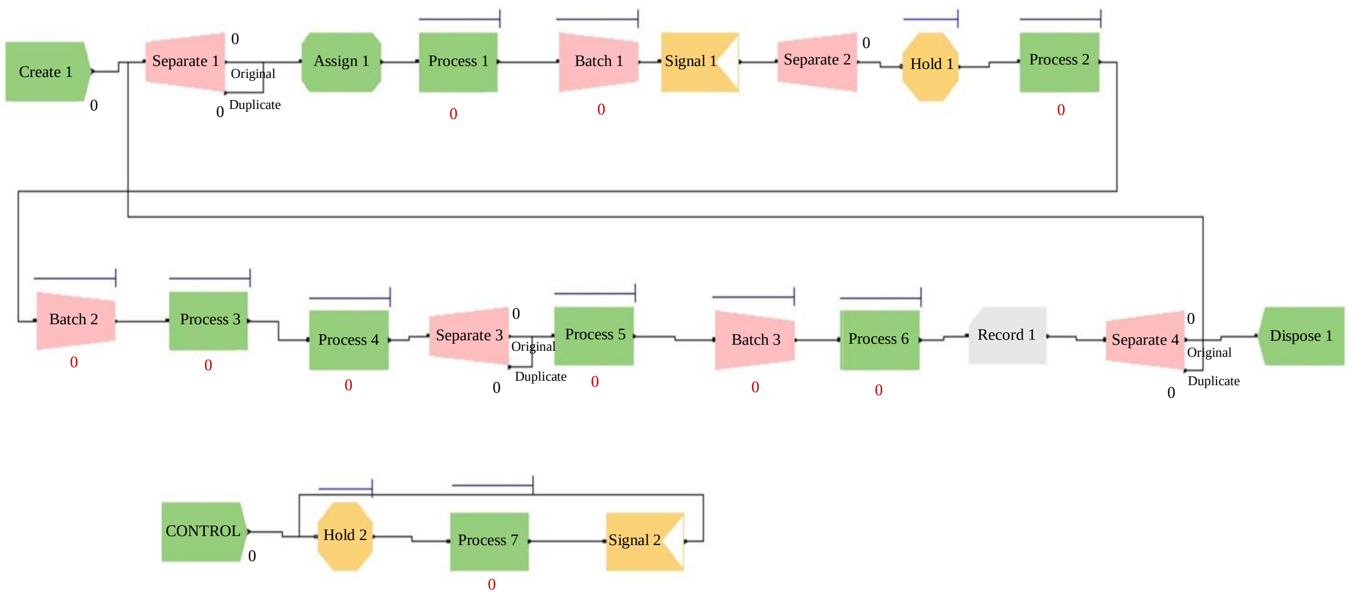

Fig. 3 Simulation model of the improved situation

Table 5. Project results

Tool	Indicators	Current	Improved
General	Productivity (garments/HH)	26	33
Work standardization	Efficiency	54.16%	68.75%
	Cycle time (min)	837.49	637.92
Kaizen	Chalking area time (hrs)	5.5	3.75
	Losses	30%	20%
5S	Tool search time (min)	40	20
	5S audit	4.6	8.6

By implementing the pilot plan, a significant improvement could be observed since the operator had the tools and materials for cutting at his disposal and eliminating unproductive times that increased the cycle time. Reducing tool search times and material availability to 15 min each and finally using standard work for the abovementioned activities. Table 4 shows the specifications for the cutting process.

As can be seen quite apart from the 5S implementation, sheets are implemented for the proper use of the inputs and the steps to follow so that the workers can establish the tasks in the same way and optimize the efficiency of the process. The Arena software was used for the simulation to visualize and analyze the improvements from implementing the tools. Figure 3 shows the simulation model of the improved situation in Arena Simulator V16 software. Secondly, the simulation is conducted with favourable results using the 5S, SW and Kaizen tools. Which can be observed in Table 5. Implementing the Lean Manufacturing model effectively increased the number of garments produced per man-hour. A significant productivity improvement was observed, rising from 26 to 33 garments per man-hour.

5. Discussion

5.1. New Potential Scenarios

According to the results obtained from the proposed model, it was possible to validate the effectiveness of the improvements implemented to increase productivity in the analyzed scenario. The results obtained were satisfactory and showed significant improvements in terms of efficiency and reduction of unproductive times. However, to guarantee the reliability and precision of the results, implementing this improvement in other similar scenarios is proposed. This will make it possible to verify the applicability and replicability of the improvements in different contexts and operating conditions. 5.2. Scenario vs Outcome.

5.1.1. Scenario 1

Scenario 1 consists of an implementation study of the 5S, Standardized Work and Kaizen tools to increase productivity in a furniture factory. The results obtained show a significant improvement in terms of efficiency and reduction of unproductive time. Regarding the implementation of the 5S, a reduction of 868.67 km was achieved in the distance travelled by employees. This indicates an optimization in the disposition of materials and tools in the work area. This improvement in the organization and layout of the elements allows workers to access the necessary resources to carry out their tasks more quickly and efficiently, thus reducing search time and minimizing interruptions in the workflow.

However, the search time for supplies and vehicles improved by 50% due to the implementation of Standardized Work. Standardizing processes and drafting detailed instructions for every activity allowed this to be accomplished. The staff can now access manuals and references that enable them to do their duties more accurately and effectively. Results from scenario one are shown in Table 6.

5.1.2. Scenario 2

The following model was developed and implemented in a textile company to reduce delays in the production line. Lean manufacturing tools were applied to achieve optimal maintenance of the processes. Table 7 shows the results of scenario 2.

5.1.3. Scenario 3

This case focuses on the implementation of Lean Manufacturing in the production line of a textile company to improve productivity. In a highly competitive environment and with increasing demand in the textile industry, Lean Manufacturing has become an effective strategy to optimize processes and maximize operational efficiency. Table 8 shows the results of scenario 3.

Table 6. Scenario 1

Indicators	Improvement
upholstered time	-14%
materials search	-50%
processing time	-18%
Standby time	-65%

Table 7. Scenario 2

Indicators	Improvement
Availability	75.34%
EO	71.01%
Products delivered on time	86.06%

Table 8. Scenario 3

Indicators	Improvement
Standby time	-21.5%
Production	+26.36%
no added value	-52.41%

Table 9. Project results

Financial Indicator	Result	Interpretation
GO (PEN)	17,940.04	The project is viable and generates value
IRR	56	The project is profitable

5.2. Analysis of Results

After successfully implementing the pilot and the simulation, the objective of increasing productivity in the cutting area has been achieved. However, it is essential to carry out an exhaustive analysis of the economic and environmental factors associated with the proposed model. This will allow us to evaluate both the monetary benefits and the impacts of sustainability obtained with the model's implementation.

5.2.1. Economic Analysis

The project's economic appraisal created an estimated 12-month financial cash flow. The expenditures associated with the legal procedure were taken into consideration.

The project is profitable based on the cash flow construction, which also yields stronger financial indicators such as the Net Present Value (VAN) of 17,940.04 and an Internal Rate of Return (IRR) of 56 percent compared to the COK (10.5 percent). The project's economic outcomes are shown in Table 9.

5.2.2. Environmental Analysis

Regarding environmental aspects, reducing waste and reprocessing has a positive impact on costs, the generation of waste, and the use of natural resources. This waste can often be recycled by other companies that need it as raw material. By optimizing the cutting process and minimizing waste, you will contribute to preserving the environment and reducing the company's ecological impact. This can translate into additional benefits, such as a better corporate image and the attraction of customers and consumers who are aware of caring for the environment.

5.3. Future Work

Future work in this context would focus on improving and optimizing the textile company's cutting process. Some focus areas could include:

5.3.1. Implementation in Other Areas

Expand the implementation of Lean Manufacturing tools to other company areas, such as packaging and enlisting the merchandise. This would make it possible to maximize the benefits of improving productivity throughout the production process.

5.3.2. Investigation of New Tools and Technologies

Explore and evaluate new tools and technologies that can improve productivity in the cutting area.

5.3.3. Training and Skills Development

Provide additional training to employees in efficient cutting techniques and the proper use of Lean Manufacturing tools. This will help strengthen the skills and knowledge of the workers, further increasing the efficiency of the process.

6. Conclusion

The research project allows us to improve the productivity of a textile company using the 5S, SW, and Kaizen tools.

Moreover, the root causes that cause low productivity were identified. Likewise, a gap of 47.6% and an economic impact of S/. 33,906.00, which represents 33.17% of the total billing loss. The first reason corresponds to excess losses with 63.85%, whose leading causes were the inefficient design of patterns (42.57%), low quality of fabrics (9.36%), and lack of training in efficient cutting techniques (7.66%).

The second reason corresponds to reprocessing (21.28%), whose fundamental causes were failures in the cut pieces (7.66%) and poor alignment of the fabrics (6.38%). The last reason corresponds to unproductive times (14.87%), whose fundamental causes were missing availability of material (4.81%), overload of tasks (3.5%), and disorder with movements (2.62%).

Implementing the pilot plan based on 5S tools was carried out together with SW and the simulation of the continuous improvement tool on the Kaizen side. Due to this, there was a reduction in excess waste, rework, and unproductive times.

The key indicators to increase productivity by improving efficiency, cycle time, and chalking area time.

The analysis of the other impacts determined that the project focuses on the cutting area, encourages continuous improvement, moderately empowers workers, and allows us to be at the forefront of technological innovation.

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