# Organizational Transformation through Intrapreneurship: Application of IoT and Poka Yoke in the Peruvian Textile Sector

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***Abstract*– This study addresses an organizational transformation model applied in a Peruvian textile microenterprise with low operational efficiency (63.54%) and cost overruns equivalent to 8% of sales. The proposal integrates Lean Manufacturing tools with IoT technology, highlighting the implementation of an IoT-supported Poka Yoke system in the cutting area. This innovation, complemented by intrapreneurship initiatives from operational staff, made it possible to refine practices such as fabric laying and reinforce an internal culture focused on optimization. As a result, defects due to excess layers in the layouts were reduced from 60% to 8.57%, which contributed to a decrease in the rework rate from 13.34% to 5.49%, strengthening the quality of the final product. At the same time, the standardization of tasks and balancing using the Operator Balance Chart (OBC) increased operational uniformity, reducing non-conformities in cuffs from 10.13% to 7.15% and in collars from 9.31% to 6.22%. Likewise, the application of the 5S methodology and visual management tools optimized the work environment, reducing unproductive time spent searching for materials from 9.12% to 6.20%. As a result, operational efficiency increased to 79.85%, approaching Brazil's international standard (80%). The model demonstrates not only its technical effectiveness but also its potential for replication as a sustainable strategy to increase the competitiveness of the Peruvian textile sector.***

***Keywords—IoT, Poka Yoke, Intrapreneurship , Efficiency, Textile industry***

## I. INTRODUCTION

Currently, the clothing industry in Peru plays a crucial role in the economy, accounting for 4.4% of the Gross Value Added in manufacturing. In addition, this sector encompasses more than 31,000 companies that generate employment for approximately 282,579 Peruvians, thus contributing 0.5% to the national Gross Domestic Product [1]. On the other hand, Peru is positioned in the global market for its pima cotton textile products, known for their high quality and value [2]. In the Latin American context, Peru ranks third among the largest exporters of clothing and textiles, with an 11.11% share, surpassed only by Mexico (52.34%) and followed by Brazil (19.71%) [3]. However, cotton garment exports have seen a worrying decline, falling from $984.745 billion in 2022 to $792.645 billion in 2023, representing a 19.5% drop and reflecting a significant contraction in exports [4]. In line with this trend, recent studies indicate that Peruvian export companies face recurring problems such as delivery delays and low product quality, which highlights their vulnerability to efficiency and competitiveness challenges [5]. In this regard, the national average for efficiency in Peru is alarmingly low, at 50.3%, in contrast to Colombia (79.12%) and Brazil (80%) [6]. This situation is largely attributed to the fact that many entrepreneurs prioritize turnover over the implementation of strategies focused on added value and waste reduction [5]. Low efficiency in the textile sector has been addressed previously through the implementation of lean manufacturing tools, achieving efficiency gains of 25% by tackling critical problems such as rework, non-standardized processes, and disorder in the work area, all of which slow down the production flow [7]. Another study reported significant improvements in production and delivery times, showing a jump in efficiency from 59% to 97.61% thanks to the reduction of defects and the consequent decrease in rework, achieving a more agile and fluid operation [8]. This study proposes an innovative solution to improve operational efficiency in a Peruvian micro-enterprise in the clothing industry, combining the Internet of Things (IoT) with Lean tools. While Lean applies tools to reduce waste, IoT enables real-time monitoring and management of key process data [9]. This integration has increased garment manufacturing efficiency by 60% and reduced defects by up to 20% [10].

Low efficiency in the textile industry is a critical problem that limits the competitiveness of companies, with the sector facing significant challenges in optimizing its production. Recent research highlights the need to implement advanced methodologies such as Poka Yoke and the Internet of Things (IoT) to reduce inefficiencies and improve quality [11]. In this context, a case study of a micro and small enterprise (MSE) manufacturing safety clothing in Peru highlights the success of Poka Yoke, which reduced set-up times by 65% and increased productivity in the sewing area by 50.37% through the implementation of locking mechanisms and visual control on the machines [12]. This methodology, together with the implementation of 5S, has proven to be highly effective in optimizing organization and reducing downtime; one successful case showed an increase in operational efficiency from 56.64% to 70.54%, allowing for an increase in monthly production and a decrease in the man-hours required [13]. Another relevant effort in the textile industry is visual management, a key tool for operational communication that facilitates real-time decision-making through the use of visual indicators in production areas. One study revealed that this methodology significantly reduced waiting times and improved communication between operators, achieving an 8.1% reduction in the defect rate [14]. Comparing these improvements with realities in countries such as Germany and the United States, where advanced technologies have been adopted, it can be seen that in Germany, the application of IoT has increased production efficiency by 25% by monitoring production lines in real time and making instant adjustments [15]. In the United States, the use of IoT in textile manufacturing has reduced maintenance costs by 30% and increased efficiency by 22% through predictive analytics systems [16]. These differences highlight the urgency for Peruvian companies to adopt innovative solutions to align themselves with global standards, improve their productivity, and strengthen their competitiveness in an increasingly demanding market.

The main motivation for this research is to increase operational efficiency in a micro and small enterprise (MSE) in the clothing sector, where 99.5% of companies are micro and small organizations that face significant barriers, such as traditional processes, lack of organization and standardization, and limited investment in technology and training [2]. These factors lead to low competitiveness and monetary losses, such as 8% of sales in unplanned cost overruns in the company under study. To address these limitations, this research develops a comprehensive and replicable model in three strategic phases, which constitutes the central contribution by applying industrial engineering tools such as Lean manufacturing and IoT, with the aim of transforming the company's operations and competitiveness. The first phase introduces poka-yoke integrated with IoT to reduce cutting errors, enabling real-time detection and prevention, improving quality, and reducing rework [17][18]. The second phase applies standardized work and task balancing (OBC) to ensure consistency in the assembly of key parts, improving the efficiency and stability of the process [19][20]. In the third phase, the implementation of 5S and visual management reduces downtime through optimal organization of the workspace and clearer communication, accelerating the availability of materials. [21] [22]. This sequential approach aims to increase the company's operational efficiency by 16.46%, from the current 63.54% to 80%, which represents a competitive standard in the sector. In addition, it offers a replicable guide that allows other textile companies to achieve a level of competitiveness and efficiency through the application of Lean manufacturing and IoT.

It is also important to consider the concept of intrapreneurship, understood as the ability of employees to promote innovative initiatives within the organization, optimizing processes and generating value [23]. Its application can increase operational efficiency by up to 22% and reduce defects by more than 15% [23]. In the textile sector, these practices have been shown to increase monthly production by 18% and reduce rework costs by 20% [24]. In Latin America, the promotion of intrapreneurship has increased innovation capacity by 25%, reducing unproductive time [25]. In the present study, this approach is related to improvement proposals based on performance data, whose implementation made it possible to reduce errors from 60% to 8.57% and increase production uniformity through standardization and task balancing, consolidating a culture of continuous improvement aligned with the organization's strategic objectives.

Finally, the research proposes a model of continuous improvement based on the integration of Poka Yoke, IoT, 5S, visual management, and standardized work. These tools make it possible to reduce errors, improve the organization of the work area, and optimize the monitoring of processes in real time. In addition, the model strengthens the culture of intrapreneurship within the organization by promoting that improvements identified from the data are translated into internal initiatives supported by employees, encouraging innovation and team commitment. The proposal seeks to increase operational efficiency, ensure better planning and distribution of tasks, and improve the quality and timeliness of product delivery. The model is based on an accurate diagnosis of current indicators and proposes a structured solution with the potential for sustained impact in the textile sector.

## II. STATE OF THE ART

This state-of-the-art analysis explores recent developments in shirt production within the textile sector. Special attention is given to the implementation of technologies such as IoT, Poka Yoke, work standardization, line balancing, visual management, and the 5S method. These innovative solutions aim to increase operational efficiency by minimizing rework and delays in production stages. In addition, the study examines current trends and analyzes how these tools can be adapted to real-world environments, emphasizing their essential role in addressing both present and future logistical challenges.

### *A. Poka Yoke to reduce errors in the cutting area in the textile industry*

The implementation of Poka Yoke in the cutting area of the textile industry has been highlighted as an effective tool for reducing errors, improving efficiency, and increasing customer satisfaction. A previous analysis showed that applying Poka Yoke to the cutting process reduced errors by 40%, resulting in fewer reworks and greater customer satisfaction [18]. Another study highlighted that integrating Poka Yoke with Lean tools reduced cutting times by 30%, optimizing materials and reducing costs [26]. The implementation of Poka Yoke systems also helped improve cutting accuracy, reducing measurement errors by 25% and avoiding time lost in adjustments [14]. Later, an article highlighted a 35% decrease in cutting defects, which contributed to a 20% increase in overall process efficiency [27]. Finally, Poka Yoke was implemented in a study of a Peruvian SME whose main problem was the low efficiency of its production line (65%), which was caused by late order delivery (71.56%), rejected units (19.17%), and non-compliance with the production schedule (9.27%). This implementation not only reduced errors by 30% but also achieved a 22% reduction in cycle time and a 36% reduction in the distance traveled by the operator. These improvements enabled the company to achieve greater production efficiency, capacity, and operational efficiency [28].

The results obtained highlight the effectiveness of Poka Yoke in reducing errors and rework in the cutting area within the textile industry. The implementation of this methodology optimizes resources and improves customer satisfaction. In conclusion, Poka Yoke is essential for achieving significant improvements in quality and operational efficiency in the textile sector. This approach improves the competitiveness of textile companies, promoting an organized and motivating work environment. The continued adoption of this methodology is key to maintaining and extending achievements in the sector.

### B. *Internet of Things for real-time monitoring of operational parameters in the textile industry*

The Internet of Things (IoT) has revolutionized the way operational parameters are monitored and managed in the textile industry. A previous study showed that implementing IoT in garment design improved design accuracy by 20% and reduced development times by 15%, enabling a faster response to market needs [10]. Subsequently, it was shown that integrating the Industrial Internet of Things (IoT) into a shirt production line resulted in a 30% decrease in downtime, thanks to real-time monitoring of operational parameters, which allowed problems to be identified and resolved quickly [29]. Finally, another analysis confirmed that the combination of machine learning and IoT improved fault predictability by 40% and optimized maintenance times, resulting in reduced operating costs and increased machine availability [30].

The results confirm the effectiveness of IoT as a key tool for optimizing textile processes by reducing downtime, minimizing defects, and strengthening product quality. Although its adoption in SMEs faces limitations associated with cost and organizational culture, these barriers can be overcome through gradual strategies and the use of low-cost solutions. In this vein, SMEs can start with small IoT projects to assess their impact and, depending on their success, scale their implementation across the entire organization [31], ensuring progressive advancement in digital transformation. In this way, IoT is consolidating itself as an essential factor in increasing the competitiveness of the textile sector in contexts of high production pressure.

### C. *Standardized work and OBC for improving quality and efficiency in garment production*

Optimizing quality and efficiency in textile production is vital in the garment manufacturing industry. Tools such as standardized work and operator balancing (OBC) have proven to be key to improving these aspects. A previous analysis showed that implementing standardized work in the sewing area improved efficiency by 30%. This improvement helped reduce unproductive time, which previously accounted for 56.35% of total lost time, or about 283.88 hours per year [11]. Additional research showed that integrating visual management with process standardization increased productivity by 25%, as it allowed the team to detect and resolve problems instantly [13]. That same year, another study demonstrated that proper implementation of standardized work reduces production defects by 15%, which was reflected in improved final product quality [32]. Another article highlighted that combining standardized work with line balancing (OBC) helped reduce waiting times by 20%, thus optimizing flow and resource utilization [12]. Finally, recent research found that integrating line balancing with standardized work resulted in a significant improvement in production performance, reducing downtime by 18% [33].

These findings underscore the impact of standardized work and line balancing on the quality and efficiency of textile production. The implementation of these methodologies not only optimizes production time, but also significantly reduces defects and improves the work environment by establishing clear procedures. For example, the 30% increase in efficiency observed in a previous study not only represents operational improvement but also indicates a more organized environment where staff can focus on productive activities [11].

In conclusion, the reviewed articles show that standardized work and line balancing are pillars for achieving significant advances in the textile industry. The results, such as the 25% increase in productivity and the reduction in defects, demonstrate how these methodologies transform conventional processes into more efficient systems, improving the competitiveness of companies and creating a more organized and effective work environment [13]. The consistent adoption of these methodologies is essential to sustain and expand these achievements in the textile sector.

### D. *5S and visual management for reducing downtime in the clothing industry*

The implementation of methodologies such as 5S and visual management have proven to be key in reducing downtime in textile production, improving efficiency and quality in the workplace. One study showed that implementing visual management alongside 5S improved internal communication by 20% and increased job satisfaction among employees by 15% [34]. In the same year, an article found that integrating visual controls with 5S reduced quality defects by 25%, thereby improving compliance with customer requirements [35]. Another approach showed that applying 5S in the production area reduced downtime by 28%, optimizing the workspace and improving overall organization [36]. Subsequently, in a textile company, it was demonstrated that the implementation of 5S increased operational efficiency by 30%, facilitating the rapid identification of problems and improving order and cleanliness in the work environment [37]. Finally, combining the 5S with other Lean Manufacturing tools reduced waiting times by 35%, resulting in a notable improvement in production flow [11].

The findings highlight the combined effectiveness of 5S methodologies and visual management as key tools for reducing downtime in the garment industry. These practices not only optimize production times but also improve work quality and increase staff satisfaction.

In conclusion, the 5S methodologies and visual management are fundamental to achieving significant improvements in operational efficiency within the clothing sector. The implementation of these tools has shown consistent results in terms of reducing downtime and improving the quality of the final product. This approach not only contributes to improving the competitiveness of textile companies against their international rivals but also fosters a more organized and motivating work environment for employees. The continued adoption of these methodologies is essential to maintaining and enhancing the progress achieved in the sector.

## III. CONTRIBUTION

### A. *Basis*

The proposed model, illustrated in Figure 4, was developed through an exhaustive literature review, in which various applicable methodologies were identified. This analysis also considered intrapreneurship as an approach that strengthens the sustainability of improvements by encouraging the adoption and maintenance of proposed solutions by employees. Based on this analysis, it was determined that the integration of poka-yoke with IoT is effective in minimizing errors in the cutting process, which, in turn, reduces the need for rework [17] [26]. Furthermore, in the context of companies in the same sector, it was evident that the implementation of standardized work and task balancing (OBC) contributes to improving product quality [38] [39]. Similarly, the practices of the 5S methodology and visual management were adopted to optimize the organization of the work area, which reduces unproductive times that cause delays in production [21] [35]. Together, the application of these six tools significantly increases efficiency in garment manufacturing.

### B. *Proposed model*

The diagnosis carried out on a Peruvian micro and small enterprise (MSE) in the textile sector reveals low efficiency in its manufacturing process, with a technical gap of 16.46% compared to the industry standard, where leading companies achieve 80% efficiency [11]. Likewise, using the Value Stream Mapping tool (Fig. 1), the manufacturing process was identified as the bottleneck, as it exceeds the takt time of 167.9 seconds by 57.3 seconds.

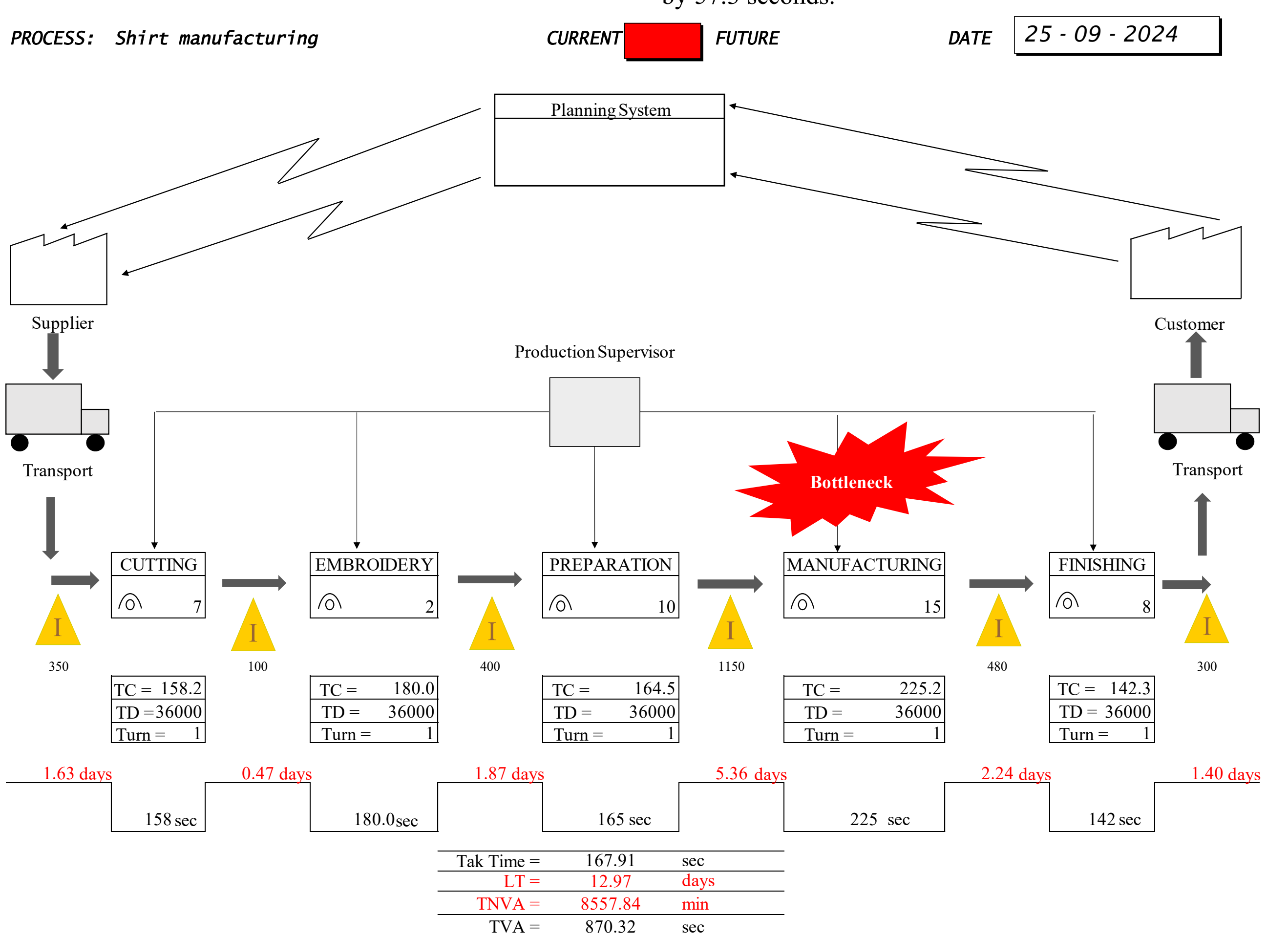

Fig. 1 Value Stream Mapping

Subsequently, a quantitative analysis was performed using P-type control charts applied to two critical variables: delayed shirts and reprocessed shirts. In the case of delayed shirts (Fig. 2), the chart showed clear instability in the process. As a corrective measure, the company temporarily outsourced manufacturing, which reduced delays, although at the cost of an unplanned additional expense of S/ 168,902.42, equivalent to 5.1% of sales. In addition, insufficient stock generated a loss of S/ 61,152.50 in lost revenue due to unsold products.

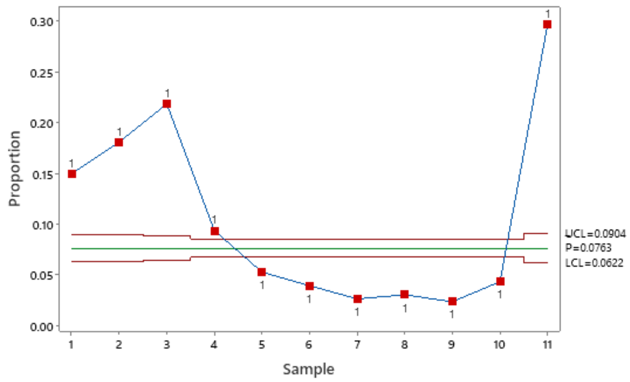


Fig. 2 Graph P of delayed shirts

Likewise, in the graph of reprocessed shirts (Fig. 3), excessive variability was observed, associated with recurring defects in the manufacturing process. This situation caused a cumulative annual total of 597.05 hours of unproductive time, generating an estimated economic loss of S/ 42,401.06. These results confirm the direct impact on operational efficiency.

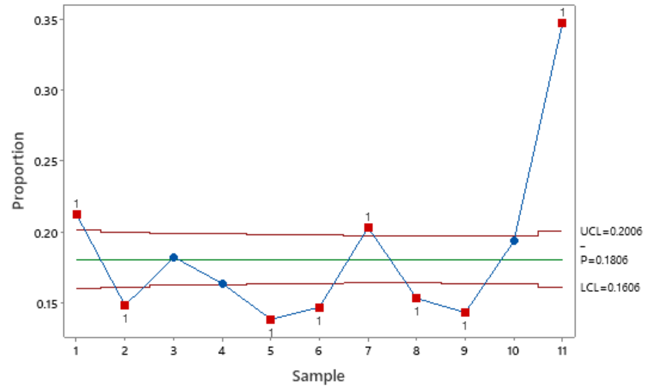


Fig. 3 Graph P of reprocessed shirts

Finally, six root causes of the problem were identified, of which the most significant are: (1) open seams on sleeves due to excess fabric stretching (26.28%); (2) collar base with incorrect distance from the start of the fabric to the stitch (22.70%); (3) incorrect distance between the cuff stitches (22.19%); and (4) waiting times for searching for materials (17.63%). Below is the proposed solution model, which incorporates the aforementioned methodologies and details each of the phases that will be carried out in this research project.

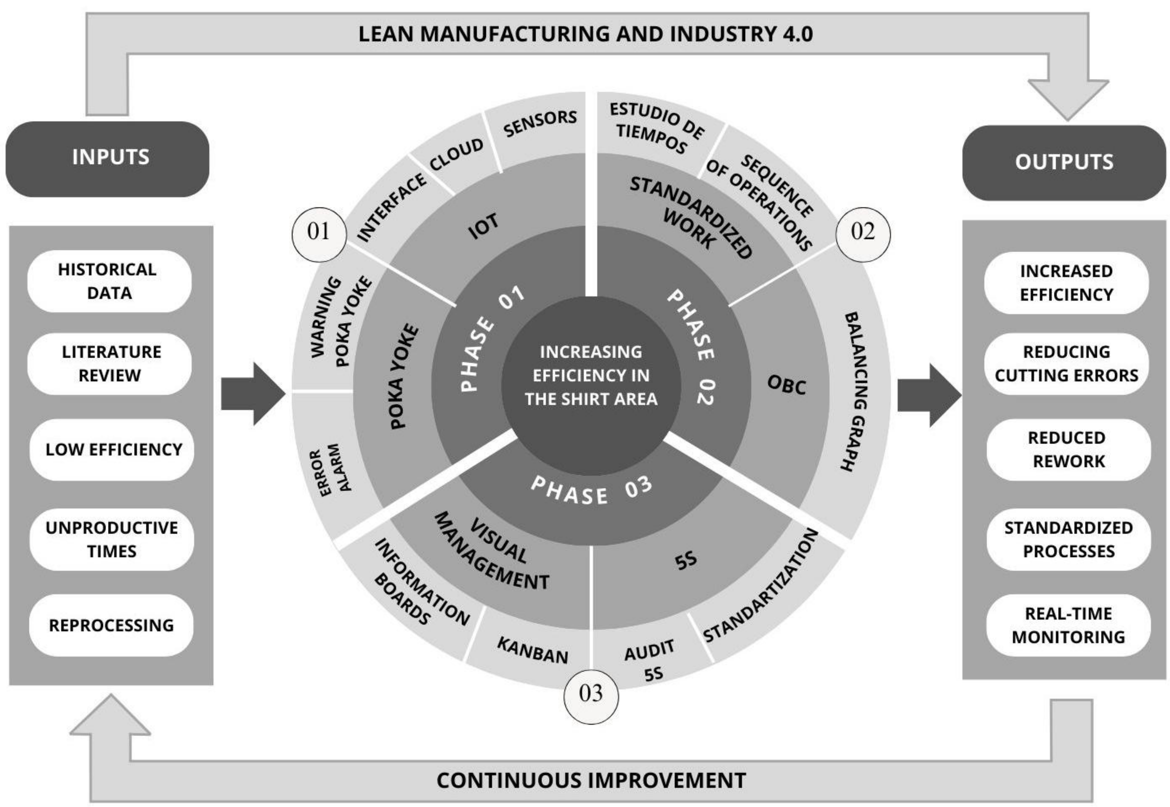


Fig. 4 Conceptual Model

*C. Design of the proposed model*

The model begins with the first phase, in which errors were identified in the cutting area attributable to excess layers in the fabric layout, as this exceeded the established optimal height of 10.4 cm [40]. This condition was corroborated by analyzing operational indicators and interviewing key personnel. To mitigate this problem, a warning Poka Yoke system integrated with the Internet of Things (IoT) was implemented. This system detects and alerts errors by measuring the height of the fabric layers before cutting, ensuring that the established limits are not exceeded [26]. Additionally, IoT sensors record anomalies in real time and send the data to a dashboard-type monitoring interface, where alerts are managed and an immediate response to potential errors is facilitated [30]. Key procedures and tools in this phase include:

- Design of a color-coding system for visual alerts (green, yellow, and red) indicating the status of the height of the overhead lines.
- Installation of ultrasonic sensors to measure layer height, connected to an ESP32 microcontroller that transmits data to the cloud.
- Integration of an alarm system for error notification.
- Transferring data to the cloud via ThingSpeak to record and visualize the height of the layers in real time via a dashboard.
- Implementation of key performance indicators (KPIs) to monitor the cutting process.

The second phase of the model focuses on standardizing work and task balancing (OBC) to improve quality, precision, and uniformity in the preparation of parts, specifically cuffs and collars. First, a comprehensive analysis of times and movements was carried out to identify downtime and define the optimal sequence of operations [11]. The application of the Operator Balance Chart allowed for the balancing of workloads and the efficient assignment of tasks among operators, ensuring consistency in the measurements and distances of each piece produced [33]. This reduces variability in the process and optimizes workflow [33]. The procedures and tools applied in this phase include:

- Operator Balance Chart for balanced task distribution.
- Time measurement for each operation in the collar and cuff preparation process, allowing for accurate evaluation of activities.
- Documentation of work sequences, establishing a standard for the order of tasks.
- Visual guides in the form of diagrams and illustrated instructions, facilitating the precise execution of tasks by operators.

The third phase of the model focuses on the implementation of the 5S and visual management in the garment manufacturing area, with the objective of optimizing organization and reducing unproductive time. Initially, problems of disorganization and loss of time in locating tools and materials were identified. The 5S methodology, comprising the stages of Classification, Order, Cleanliness, Standardization and Discipline, allowed the work area to be restructured to ensure quick access to essential resources [37]. This process was reinforced by visual management, using Kanban boards that show the state of progress in production, daily objectives and goals achieved [34]. The information boards and visual indicators facilitate operators and supervisors to monitor in real time the achievement of objectives and the availability of materials [34]. The main procedures and tools applied in this phase include:

- Execution of an internal audit to train and define the functions of the 5S committee.
- Use of green, yellow and red cards to classify tools according to their frequency of use and necessity.
- Development of a cleaning program with specific dates and established goals.
- Implementation of signage in the garment shop, including markings and labeling of work areas.
- Forms to standardize the 5S steps, ensuring consistency in the application of the method.
- Kanban and information boards to facilitate progress tracking.

## IV. VALIDATION PROPOSAL

*A. Poka Yoke and IoT Validation*

In order to technically validate the proposal, a pilot project was developed comprising a visual prototype of Poka Yoke based on color coding, which was integrated into the fabric laying process. This system allowed the operator to identify in real time whether the height of the fabric was within the permitted range, immediately alerting them in the event of deviations.


Fig. 5 Poka Yoke prototype pilot

The pilot began with the estimation of the sample size through simple random sampling. Based on ten preliminary observations, a sample size of 35 was established. As shown in Table 1, the warning Poka Yoke prototype recorded 10 cases of excess lay height, resulting in an error rate of 28.57% in the cutting process. However, since its effectiveness relied exclusively on the operator's response, its performance was limited. To overcome this limitation, an automated system with IoT technology was implemented, whose integration reduced defects to 8.57% through continuous monitoring and real-time alerts, thereby consolidating a higher level of process reliability.

TABLE 1
RESULTS OF THE POKA YOKE AND IOT PILOT STUDY

| | Number of Observations | Cases of height exceedance | Cutting error rate |
|---|---|---|---|
| **Poka Yoke** | 35 | 10 | 28.57% |
| **IOT** | 35 | 3 | 8.57% |

Fig. 6 shows the IoT integration flow. It starts with ultrasonic sensors that measure the distance between the device and the surface of the cable. The data obtained is processed by an ESP32 microcontroller programmed in Arduino, which calculates the height in real time. If the pre-set limit is exceeded, the system automatically activates a warning alarm to alert the operator. In addition, thanks to the ESP32's Wi-Fi connectivity, the information is transmitted to the cloud via the ThingSpeak platform, where it is stored and displayed on a real-time dashboard, allowing for monitoring and traceability of the process.

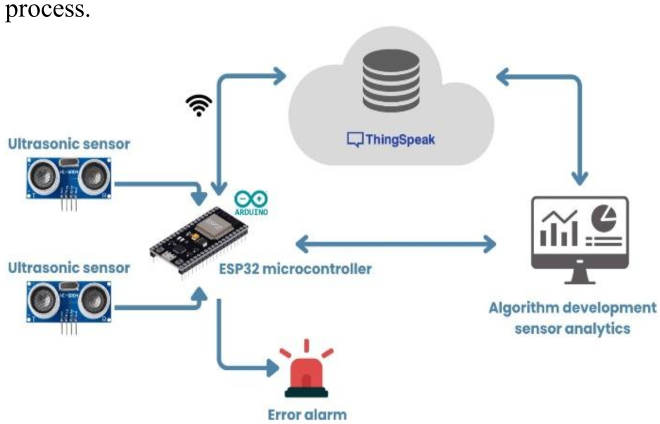


Fig. 6 IoT integration flow

Fig. 7 shows the height report generated through the ThingSpeak platform. The record shows that the final height of the block of wires reached 9.5 cm, a value that is within the established optimal range. Likewise, the measurement was recorded with its corresponding date and time, which ensures traceability and control of the process in real time.

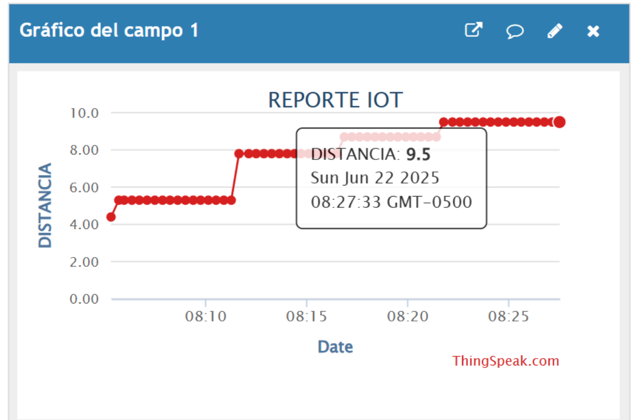


Fig. 7 Height report on the ThingSpeak platform

*B. Validation of Standardized Work and OBCs*

The validation of the standardized work and operator balance (OBC) was carried out through the analysis of times and movements in the manufacturing area. Initially, imbalances were identified in the distribution of tasks, generating bottlenecks and idle times. Through the time study, operating standards were defined and detailed worksheets were prepared.

Subsequently, the OBC tool was applied to redistribute operations evenly among the stations, improving the workload per operator. As a result, a significant reduction in non-productive times and an improvement in line efficiency were achieved, reaching levels above 90%. This validation confirms that the joint use of standardized work and OBC contributes directly to optimizing processes and increasing productivity in textile manufacturing environments.

*C. 5S Validation and Visual Management*

The validation of the 5S methodology and visual management in the apparel area was structured in eight stages. Initially, the number of observations was determined by considering seven observations. Next, a diagnostic audit was carried out, which showed a 28% compliance, indicating the need for structured intervention.

To this end, a 5S committee was formed, where the actions were approved by general management. Training and induction sessions were held for operating personnel, focusing on the principles and benefits of the methodology. During the classification phase (Seiri), unnecessary inputs, tools and equipment were identified and removed using control cards, while in the order phase (Seiton), materials were reorganized by frequency of use, using a color-coding system.

**Before** **After**

Fig. 8 Photographic evidence

In the cleaning stage (Seiso), monthly schedules and individual checklists were implemented, supported by daily inspections and visual audits.

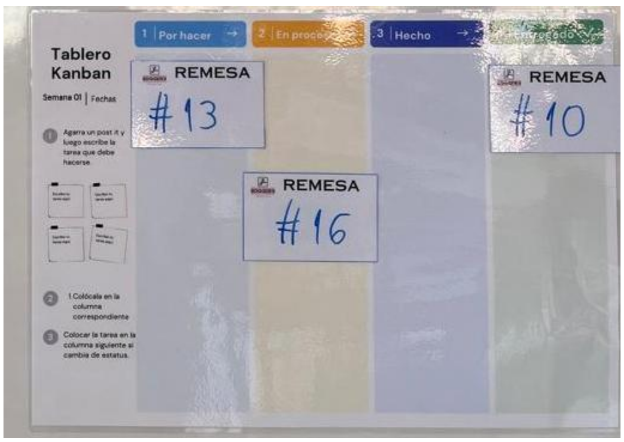


Fig. 9 Kanban board

Standardization (Seiketsu) was achieved by means of checklists that allowed an objective evaluation of compliance with the first three stages, with favorable results thanks to the participation of personnel and supervision by management.

Finally, in the maintenance phase (Shitsuke), a subsequent audit revealed a 90% compliance level, reflecting an improvement over the initial audit. Mechanisms were put in place to ensure the sustainability of the system, including monitoring by the 5S committee and incorporating suggestions for continuous improvement through forms designed for this purpose.

### D. *Indicators of the model*

Table 1 shows a comparative summary of the main project indicators before and after the implementation of the pilot plan, as well as the results achieved during this phase. These data allow a quantitative evaluation of the impact of the tools applied. Regarding the main efficiency indicator, a significant improvement is observed, going from 63.54% in the initial scenario (As Is) to 79.85% after the implementation of the pilot, getting significantly closer to the proposed objective of 80% (To Be). On the other hand, in Phase 1, the rate of wrong cuts, which initially was 60%, was drastically reduced to 8.57%, evidencing the effectiveness of the solutions implemented in the cutting stage. These results reflect a substantial improvement in the operational efficiency of the process and validate the proposed model as a viable strategy for continuous improvement in textile companies.

TABLE 2
PROJECT INDICATORS

| | Indicator | As Is | To Be | Piloto |
|---|---|---|---|---|
| **Main indicator** | Efficiency | 63.54% | 80% | 79.85% |
| **Phase 1** | Wrong cut rate | 60% | 7% | 8.57% |
| | Percentage of rework | 13.34% | 6% | 5.49% |
| **Phase 2** | Cuff nonconformity rate | 10.13% | 6.33% | 7.15% |
| | Neck nonconformity rate | 13.24% | 6.33% | 6.22% |
| **Phase 3** | Percentage of non-productive time | 9.12% | 5.54% | 6.20% |

### E. *Financial Results*

For the development of the project's economic flow, key variables such as the income tax rate (29.5%) and total investment, broken down into fixed assets and operating resources, were considered. This financial structure made it possible to calculate fundamental indicators for the economic feasibility assessment, such as Net Present Value (NPV) and Internal Rate of Return (IRR).

TABLE 3
ECONOMIC FLOW

| | | |
|---|---|---|
| **NPV** | S/ 15 604.96 | > 0 (Accept) |
| **RBCF** | 1.49 | > 1 (Accept) |
| **IRR** | 52% | |

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## V. CONCLUSIONS

The implementation of the Poka Yoke system with IoT technology at the cutting station reduced errors due to excess height from 60% to 8.57%, improving process accuracy, reducing material waste, and increasing the quality of the final product. This progress was enhanced by the intrapreneurship initiative of the workers, who actively contributed to the optimization of fabric laying and the consolidation of a culture of continuous improvement.

Production efficiency reached 79.85% after the implementation of the improvement plan, which reflects a greater operating capacity to meet demand without affecting quality standards or delivery times, optimizing the use of human and material resources.

The application of the 5S methodology together with visual management tools generated a reduction of up to 6.20% in unproductive time in the manufacturing area, demonstrating its effectiveness in improving order, cleanliness, and standardization in the work environment.

The application of Standardized Work and OBC in Phase 2 reduced the nonconformity index in cuffs from 10.13% to 7.15%, and in neck from 13.24% to 6.22%, showing improvements in product quality through the standardization of tasks, the balanced distribution of loads and a more precise execution by the operators.

The economic analysis showed the profitability of the project, with an IRR of 52%, an NPV of S/ 15,604.96 and a Benefit/Cost ratio of 1.49, results that support the technical and economic feasibility of the proposal, as well as its possible replicability in other areas of the company.

## Appreciation/Recognition

We express our sincere gratitude to our advisor, an expert professional who dedicated his time and knowledge to providing us with valuable information, which was fundamental for the development of this work. We also thank our families for their constant support and encouragement, which has motivated us in every step of this path.

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