Production model based on Lean Manufacturing and BPM to reduce the rate of returns in SMEs of garment printing

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Abstract

Small and medium-sized companies in the textile sector have deficiencies in the production area. It happened because they do not have a standardized process and adequate machine maintenance management. For this reason, analyzing the initial diagnosis of an SME company dedicated to textile printing presented problems in design and printing. Based on this, this research developed a proposed model to reduce the return rate, improve work areas' organization, and optimize delivery times. The production model is developed based on the Lean BPM (Business Process Management) and TPM (Total Productive Management) tools through a 5s continuous improvement approach. The improvement proposal is validated in the Arena software, reducing the failure rate of the machines and the rate of returns from 7.95% to 5.97%.

Keywords
5S, Work standardization, textile sector, Lean tools, BPM.

1. Introduction
In the current context, industrial textile companies are more competitive worldwide since they face a more demanding market that demands higher quality products.(Mireles & Estrada, 2017).This sector represents 9.7% of total non-traditional exports, with the United States as the main consumer with a 53.3% share.(*ComexPerú - Sociedad de Comercio Exterior Del Perú*, n.d.). Therefore, the clothing textile sector is one of the most important sectors in the country and represents 10% of companies of the entire manufacturing industry and generates around 400,000 jobs.(Gestión, 2019). In 2020, the textile and apparel sector fell by 32.1% due to the decline in the apparel subsector, with a drop of 35.9%, considering that the level of performance has been lower compared to previous years(Instituto de Estudios Económicos y Sociales, 2021). These results harm the growth of textile companies, preventing the improvement in the performance of garment manufacturing. This problem was identified in other investigations around the world, where the main causes were identified: stamping failures, customer disagreement, or lack of stock. Likewise, the company Baguer SAS registered 5.38% of returns to reduce the client's management time (Jessica Dayanna Carrillo Díaz, 2018). Another investigation carried out in Peru details a problem in the production process, which it identifies as the main cause of the inadequate maintenance and incorrect distribution of the machinery, registering a 5% return rate of products(GONZAGA, 2018). This shows, as mentioned above, how textile companies register a percentage of returns related to causes or deficiencies in the face of the problem. Due to this, it was essential to start from a company that shows these deficiencies in various internal areas to determine the main causes and possible solutions. For this reason, the diagnosis of the EYM textile company is evident that the % of returns is high. The KPIs of perfect order indicators are also analyzed to determine which factor we must focus on, thus identifying the causes of the problem: machine failure in the stamping area and lack of a standardized method in the clothing area. This research offers a new perspective of the Lean BPM methodology with TPM and standardization of work to reduce returns. However, no article evidence cases of resolving this problem in Latin America, which is based on the ignorance that other companies may have by not recognizing this deficiency in their internal areas. The investigation is divided into several points that explain the steps involved in the proposed investigation. Then, the research design is presented. Finally, the validation of this research design is shown with the conclusions of the study developed.

2. Literature review

The research was carried out after an exhaustive review of the literature, including 40 scientific articles related to the project that was less than seven years old. In addition, the featured articles are presented below.

2.1 Lean Manufacturing

Lean is an improvement methodology that helps reduce errors in meeting the quality standards of a product or service. This is how the power of Lean Manufacturing lies in continuously discovering the opportunities for improvement hidden in the company because there will always be waste that can eliminate.(Franco, 2017). Lean manufacturing aims to optimize the use of resources in any production process by eliminating waste and focusing on improving process efficiency to impact productivity and ultimately provide a competitive advantage. Integrated models are developed for the application and demonstration of the effectiveness and practicality of lean manufacturing; through simulations and studies of different companies(Dave & Sohani, 2019). Likewise, it is analyzed that can apply Lean Methodology to diverse business sectors such as clothing companies; so, the objective of the work investigated in the article was to design and implement an action plan for continuous improvement through Lean Manufacturing tools, which included the 5s and the Visual Control. The Methodology included: researching state of the art, diagnosing the current condition, designing, and implementing the action plan and the required documentation, and finally, measuring effectiveness. With the pilot implementation of this project, the times that do not add value were reduced by 12%(Pérez et al., 2016). In this way, It is used to increase productivity by studying the work of a metalworking company. The company's problem was poor template design and unwanted worker fatigue, leading to increased cycle time and reduced productivity. New techniques and work methods were implemented to minimize downtime and increase productivity(Gujar & Moroliya, 2018).

2.2 Total Productive Maintenance

The efficiency of TPM development in organizations is analyzed in detail through the planning of objectives and Methodology; This allows improvements in equipment and operations to be achieved by reducing the failure rate.(Franco, 2017). Likewise, TPM is Total Production Maintenance, which emerges as a new "Maintenance" philosophy, integrating it into the Production function globally, not as an end but to reduce production costs. The goal is to achieve maximum efficiency(Shen, 2015). Finally, a study is carried out on applying the integrated TPM system with RCM in a textile factory to improve the efficiency of the equipment and reduce the high rate of failures due to unplanned stops or loss of performance.(Sacristán, n.d.).

2.3 5s Methodology

The 5S Methodology is considered the most qualified Lean tool for companies that follow known standards to obtain international certification.(Zhou, 2016). This tool, whose name comes from five Japanese words, Seiri (order), Seiton (put in order), Seiso (shine), Seiketsu (standardize), and Shitsuke (hold), makes it easier to carry out activities because it creates an organized work environment and clean inside the company(Médico et al., 2018)[fifteen]. Implementing this tool in the production area saves costs and can significantly change the company's organizational culture, which means benefits for the future. This method is effectively demonstrated in companies from different sectors(Carrillo Landazábal et al., 2019). An investigation was carried out on the implementation of 5S in a spare parts warehouse. With this, they seek to improve working conditions so that their workers can carry out their activities in an organized, orderly, and clean manner. What was achieved with this work was to set up a system where orders are taken correctly, reducing errors in the entry and exit of material and having correct stocks without shortages or surpluses.(Achamu et al., 2018).

2.4 Business Process Management

It focuses on improving processes' effectiveness and efficiency through their evaluation and continuous improvement to increase productivity, applying tools such as process standardization, correct decision making, elimination of redundant activities, and rational management of the resources(Fernandes et al., 2021). This Methodology allows designing, modeling, and managing process flows to identify and analyze existing problems and propose improvements and a redesign that adjusts to each company(Elahi & Bilal, 2020) (Enríquez et al., 2019). It is mainly a process management design to eliminate activities that are not generating value for the process or the final product and reduce excess materials to achieve the value of the process and maximum customer satisfaction.(García-Alcaraz et al., 2019). In addition, process management facilitates production planning and process control. The results show an increase of 71.87% in productivity, and the cycle time is also reduced by 16.67%.(Quiroz-Flores et al., 2022).

2.5 Kanban

Kanban is a signaling methodology to improve control and ensure projections on-demand or production. Eliminate unnecessary activities in the production process and make it easy to track progress on the calendar(Mohan Prasad et al., 2020). It uses visual signals such as cards, boards, or electronic devices that aim to activate the replenishment process and indicate to workers how much material is needed to produce what is necessary.(Castellano Lendínez, 2019). The lack of supplies generates several inconveniences; the most seen are the delays in the processes, which create unnecessary waiting times(Samanamud Natividad et al., 2020). Kanban aims to manage production, reduce inventories and mitigate tasks that do not add value to the production system.(Castellano Lendínez, 2019).

3. Methods (Proposed model)

Figure 1 shows the proposed model, which is based on the reduction of the rate of returns using three fundamental components. The first is the organization of the warehouse and work area; through the 5s Methodology, it will be possible to eliminate unnecessary movements and reprocesses in the flow of work and organize and maintain adequate cleanliness in the stamping and design area(Martínez, C., & Barcia, 2010). The second is reducing defective products; this phase focuses on implementing continuous improvement tools related to the Lean Manufacturing methodology.(Sophie Tejeda, 2011). In the first place, standardized work will make it possible to generate a uniform process capable of improving and making each process more efficient. Secondly, the "Total Productive Maintenance," better known as TPM, is divided into two essential pillars such as autonomous and planned maintenance; The first will consist of maintaining the useful life of the machines, avoiding the deterioration of the components, and carrying out industrial maintenance tasks by the operators. The second corresponds to the equipment's incremental and sustainable improvement to achieve zero breakdowns. Finally, it optimizes delivery times through daily management, training, and standardized work. These will improve the delivery times of production orders

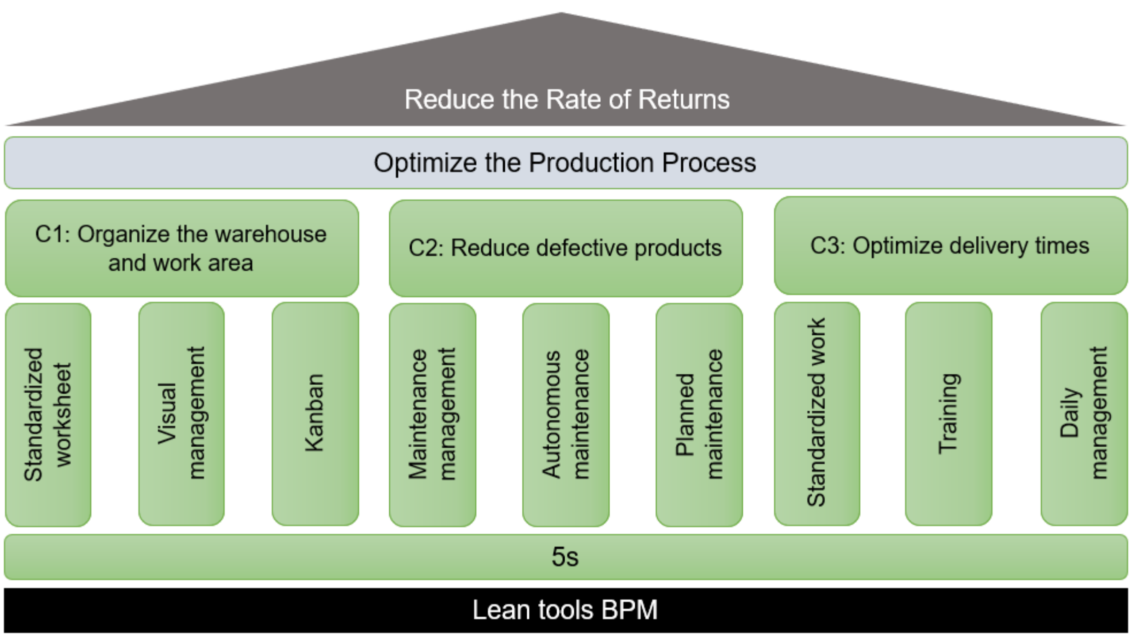

Figure 1. Contribution of tools in the proposed improvement

3.1. Phase 01 – Organize the warehouse and work area: The starting point of this investigation was to make the diagnosis of the case study. Then, the proper collection of data and information on the company's primary operations were carried out. It was proposed to organize the warehouse and work area with standardized worksheets for the operators of the stamping and design area; In this way, visual management standardizes processes by measuring progress and improvements in the operation, and the Kanban tool would allow you to benefit from visual management using colored cards and improved distribution of work that attributes a reduction in waiting times. It should be taken into consideration that with the results obtained and the previously outlined goals, it will be possible to compare the KPIs obtained after the simulation of the implementation of the proposed model. The indicators are presented below.

3.2. Phase 02 – Reduction of defective products: Within this stage, it is sought to involve all the selected tools with TPM, including maintenance management and autonomous and planned maintenance. These pillars of TPM help us reduce the failure rate of machines and the rate of defective products.

3.3. Phase 03 - Optimize delivery times: This component aims to reduce delivery times with improvement tools such as standardized work, training, and daily management. These make it possible to improve and reduce the delivery times of printed polo shirts.

3.4. Process proposal.

Figure 2 It shows the process for implementing the methodologies, specifying each component is part of the model to reduce the rate of returns in the textile company.

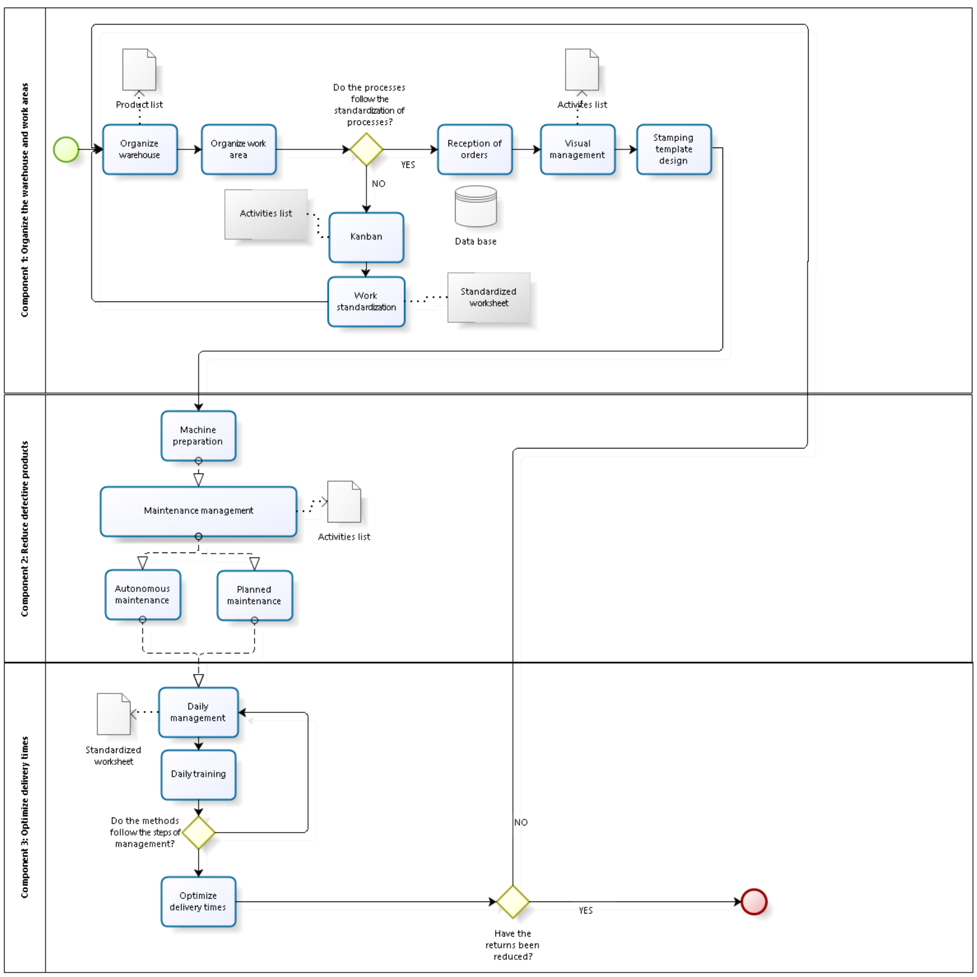

Figure 2. Model proposal processes

3.5. Indicators Model

The indicators of the proposed model are presented below.

Returns rate: It is the number of returns that have been generate.

$$Return\ rate = \frac{Returned\ products}{Sold\ products} x100\ (1)$$

Audit rating 5s: It is the average of the five audits carried out.

$$Audit\ Qualification = Average\ of\ the\ 5\ audits\ (2)$$

Mean time between failures (MTBF): Indicates the operational reliability of the machine.

$$MTBF = \frac{Total\ time\ available - time\ wasted}{Number\ of\ stops}\ (3)$$

Mean repair time (MTTR): Total time of corrective maintenance between the number of actions during a period.

$$Delivery\ fullfilment = \frac{Orders\ delivered\ as\ agree}{Total\ orders\ delivered}\ (5)$$

Delivery Fulfilment: It is the relation between the orders delivered correctly and the total number of orders.

$$MTTR = \frac{Total\ corrective\ maintenance\ time}{number\ of\ repair\ actions}\ (4)$$

Average time of attention of an order: It is time it takes to attend a production order.

$$Average\ order\ handling\ time = Total\ production\ time\ (6)$$

4. Validation

The simulation of the current situation and the improvement proposal made in the Arena program is carried out to validate the improvement proposal.

4.1. Initial diagnosis

Currently, the type registers high rates of returns; this is due to the high frequency of failures of the stamping machines. The economic impact generated is 7.33% of the gross profit, costing 40,214 PEN. Maintenance costs amount to 11,875 PEN. The leading causes of stamping failures are: (a) machine failure and (b) lack of a standardized method. The leading causes of machine failures are: (a) Insufficient monthly maintenance of machines, (b) cleaning, adjustment, and lubrication of machines, and (c) overheating.

4.2. Validation design

The model proposed in this case study will be verified by performing the simulation in the Arena software to demonstrate the effectiveness of the 5s tool, the Lean tools (autonomous, planned maintenance, Kanban, and standardized work), and process improvement with BPM. For the implementation of autonomous maintenance, the first procedure was the organization of the warehouse and work area through a standardized worksheet, visual management, and Kanban; this will allow having the right tools in place and not delay the search for tools or raw material. Second, operators were trained to maintain the useful life of the machines and, in turn, reduce defective products. After the training, Rules of cleanliness and order were established in the workstations of the design and stamping area. The planned maintenance management plan was evaluated by the production manager to determine performance records through an activity compliance checklist. Finally, delivery times were optimized through standardized worksheets, training, and daily management; this allowed to reduce the saturation of the operator and optimize the orders served. In addition, productive maintenance and Lean leadership create a synergy of maintenance management to increase the availability of the delivery times were optimized through standardized worksheets, training, and daily management; this allowed to reduce the saturation of the operator and optimize the orders served. In addition, productive maintenance and Lean leadership create a synergy of maintenance management to increase the availability of the delivery times were optimized through standardized worksheets, training, and daily management; this allowed to reduce the saturation of the operator and optimize the orders served. In addition, productive maintenance and Lean leadership create a synergy of maintenance management to increase the availability of the machines(Palpán-curisinche et al., 2020). From the collection of the data, the average duration of attention to order takes 240 hours, the stops of the machines and separate calculations of the MTBF (mean time between failures) and MTTR (mean time to repair) of the four machines of stamping show an average of MTBF equivalent to 489.6 hours and the MTTR was obtained an average of 86.4 hours per year for the machines. (Table 1)

Table 1. Results of indicators of the simulator

Indicator	Current	Expectation
Return Rate	7.95%	5.97%
Audit Qualification	39.2%	70%
Mean Stop Time (MTTR)	86.4 hours	56 hours
Mean Time Between Failures (MTBF)	1296 hours/year	2248 hours/year
Delivery Fulfilment	92%	95%
Average order handling time	240 hours	210 hours

5.2 Simulation of the proposal

This simulation model is the representation of the improvement proposal. A complete analysis was carried out with the improvement tools, eliminating unproductive times, and improving the stamping process. The Arena software, which can be seen in Figure 3, reduces the rate of returns and reduction of stop frequencies.

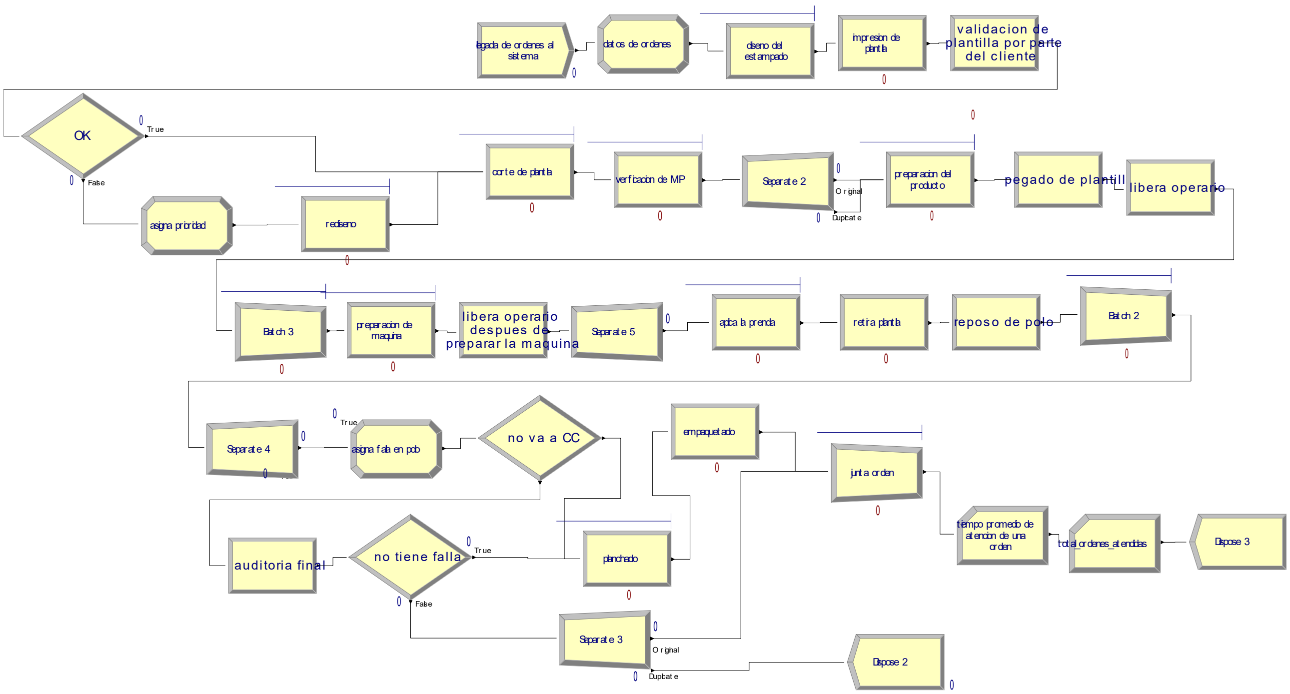

Figure 3. The proposed model simulated in the final state

The proposed model begins with the arrival of production orders until it is delivered to the customer. The optimal number of replications for the model was determined to be 282 to ensure statistical validity and reliability of data. The following Table 2 shows the results of the simulation.

Table 2. Current situation vs. Improving situation

Indicator	Current	Expectation
The average number of machine failures per year	5	2
Average order handling time (h)	223.81	131.12
Mean Stop Time (MTTR) (h)	86.4	48
Mean Time Between Failures (MTBF) (h/y)	1296	3396
Saturation of ironing operators (%)	97.22	91.91
Saturation of the stamping operator (%)	93.82	82.85

One of the important indicators is the attention time of order; by implementing the work standardization tools, 5s, TPM, and BPM in the design and stamping area, it was possible to reduce operation times and execute the tasks in a specific time to this meeting the delivery times to the client with a total reduction of 92.69 hours between the current situation and the proposal. Another indicator is the number of machine failures, three failures per year were reduced by implementing preventive and autonomous maintenance. The saturation percentage of ironing and stamping operators was decreased by 5.31% and 10.97%, respectively, by implementing work standardization, 5s, and Kanban. In addition, it was possible to increase the number of orders served per year from 210 to 226. Finally, the MTBF managed to raise 307. 2 hours per year, and the MTTR decreased to 28.8; these indicators are important because the difference is observed when preventive and autonomous maintenance is implemented. As a result, the company will reduce maintenance and reprocessing costs and increase customer satisfaction.

6. Conclusions

Implementing the Lean BPM tools was fundamental for validating the project because they correctly intervened in the leading causes of the investigation. In this way, the project reduced the rate of returns by applying the improvement tools from 7.95% to 5.97% and the rate of failures by 40%. On the other hand, it is recommended to have planned and autonomous maintenance of the machines to reduce defective products.

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