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Lean Manufacturing Model for production management to increase SME productivity in the non-primary manufacturing sector

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Abstract. Currently, there is a large percentage of small and medium-sized enterprises (SMEs) in the Peruvian textile market that show economic loss because of the payment of penalties to customers, which are incurred owing to the delay in the delivery of order batches. This is due to poor production management and a lack of focus. The manufacturing sector is essential because of its high contribution to the country's gross domestic product. Currently, SMEs do not employ methodologies that help improve production and process management as they do not realize how important and necessary the methodologies are, in addition to how complex these may be. Therefore, this paper will propose a production management model designed for SMEs in this sector, based on Lean methodology where the objective is time reductions and production increases as well as exerting changes to the organizational culture. Thus, this model will help organizations to avoid incurring economic losses because of the payment of penalties for orders not delivered on time. To validate the present model, a time simulation was performed in the manufacturing area of a textile company. The result of this project was positive, since there was a 25% increase in productivity and a 20% reduction of takt time with respect to the initial data.

1. Introduction

The textile sector represents a significant share of the world's gross domestic product (GDP). In 2017, the worldwide participation indicator was 3.4%. In Peru, this industry represents 8.9% of the entire manufacturing production and 1.3% of the national GDP (2014). In addition, textile exports had increased by 11.5% over the previous year. SMEs represent 99.5% of Peru's business sector, and of this percentage, 16.5% are companies engaged in manufacturing garments (Ministry of Production, 2015). Further, 47.8% of these companies are located in Lima. [1][2][3] However, a competitive disadvantage for most SMEs in Latin America is their often informal and unprofessional management. This is due to a lack of knowledge of the various business management tools, which reduces effectiveness, profitability, and sustained development. [6]

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This study has an economic justification, since the use of a production model based on Lean tools and process management will allow the company to reduce downtime and fulfill order batches on time, thus avoiding penalties. In the sectorial analysis, it was identified that 77.3% of SMEs deliver 43.5% of all orders late, which is primarily due to deficient production management. [7] Through the literature review, it was found that the Lean manufacturing philosophy has a positive impact on companies. A study found that the development of Lean tools in a textile company managed to reduce the duration of activities that do not add value to the process; this led to economic savings of $25,916,485. In addition, this implementation achieved qualitative benefits, such as the improvement of the work environment, a better image of the work area, the creation of a teamwork culture, and a sense of belonging to the company. [5]

Although there is a considerable amount of information about the application of Lean manufacturing tools in companies, few studies have addressed the impact of Lean on SMEs and even less have focused on process management in textile SMEs. In the Peruvian reality, about 70% of these companies are informal. [6] Therefore, it can be deducted that the implementation of Lean manufacturing or process management is scarce. Based on the aforementioned, this paper proposes the implementation of a production management model based on Lean tools (5S and Kanban), supported by knowledge and change management, with the aim of improving employee skills, increasing profits, and reducing penalties due to late order fulfillment. The model is based on 5S implementation, using Kanban cards, throughout which knowledge and change management will be introduced.

This article has been structured in four main sections. In the first section, an intensive review of the literature on Lean manufacturing tools and process management was conducted. In the second section, the proposed methodology is described, focusing on the contribution of the study. In the third section, the validation of the proposal is developed. Finally, in the fourth section, the conclusions of the study and the bibliographical references are detailed.

2. State of The Art

The literature review has allowed us to learn about techniques and methodologies that have been used by organizations to achieve better production management, which uses a set of tools, methodologies, and resources to maximize process or company productivity levels [11]. Among the techniques used to improve production or processes by reducing cycle times are Lean manufacturing, Six Sigma, and reengineering. [12] [13]

The authors define each of these techniques from different points of view. Lean manufacturing can be defined as a systemic and systematic approach for identifying and removing waste or activities that do not add value through continuous improvement by making the product and the information necessary to produce a quality product flow. Moreover, Six Sigma is an improvement methodology developed to improve process quality with the goal of creating a near-zero defect quality strategy by improving customer satisfaction and financial results. Finally, process reengineering is a means to achieve sweeping changes in performance, taking costs, cycle times, service, and quality as measurements and seeking to improve customer-related processes to add real value. After reviewing all the aforementioned concepts and definitions, we can note that all these methodologies serve the purpose of improving customer-related processes within an organization and that also contribute value to the product offered. However, only the Lean manufacturing methodology can be applied to all companies and their levels regardless of company size since the methodology does not require large investments and results may be observed in the short term. [14] [15] [16] [17]

3. Contribution

3.1. Model Proposed

Based on the research conducted and the comparative analysis of different methodologies, a model was developed wherein the important dimensions of production management models were assessed. As internal MSE processes were considered as essential to product development, we combined the

Lean manufacturing methodology with change and knowledge management to guarantee the successful implementation of the model since change and knowledge management focus on the most important aspect: the human factor.

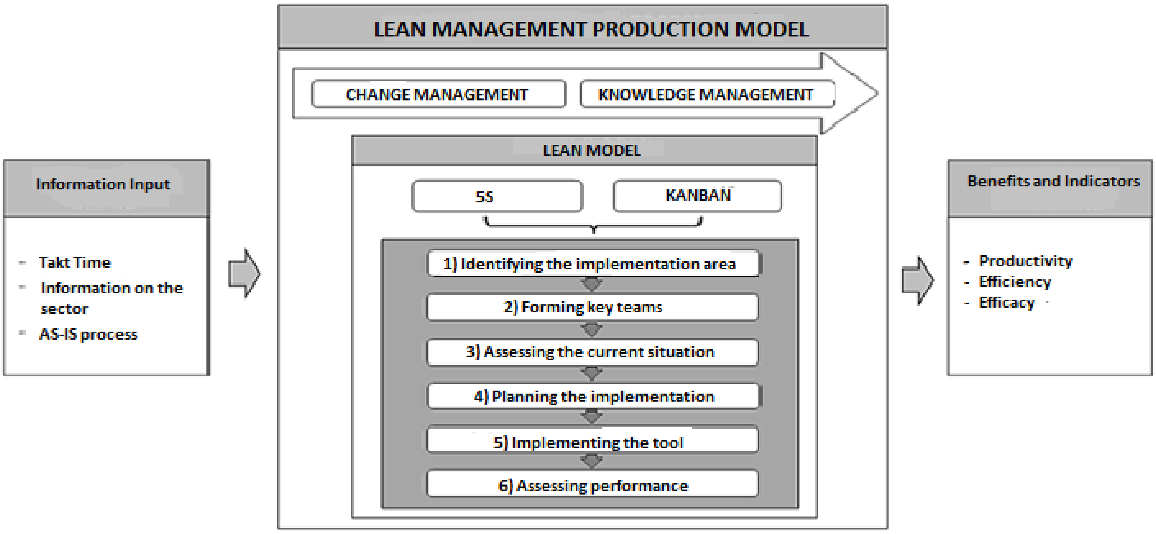

Figure 1. Detailed view of lean management production model

3.2. Components of the Model Proposed

3.2.1. Knowledge Management. Knowledge management is a tool that allows for the possibility of assessing your own knowledge and the importance of new knowledge in an organization. It is necessary to know the area and the personnel that will be involved in the management model.

3.2.2. Change Management. Change management is a structured approach to managing change issues primarily related to people and the organization to achieve initial objectives. The objective of this management is to evaluate and create a contingency plan to deal with changes in work activities, improve communications, and provide training to counteract resistance.

3.2.3. Lean Manufacturing Model

- **First Stage:** Identifying the implementation area. A reduced physical area should be selected to be used as a pilot area. After the pilot test, the implementation may be expanded to other areas of the company.
- **Second Stage:** Forming key teams. A key team will be in charge of the proper development of the implementation project.
- **Third Stage:** Assessing the current situation. An initial audit of the selected area will be conducted to acquire an awareness of the current situation and thus manage current knowledge.
- **Fourth Stage:** Planning 5S and Kanban implementation within the project.
- **Fifth Stage:** Implementing the 5S and Kanban in the work area. In this stage, all phases will be developed for each of the selected tools.
- **Sixth Stage:** In this stage, performance evaluations and final audits will be carried out after 5S implementation. Subsequently, Kanban will be applied in order to verify whether the project reached the desired results.

3.3. Process of the Proposed Model

This section presents a flowchart that will graphically represent the procedures that will be carried out during the development of the project. As mentioned above, tools will be used to help the human factor cope with change. This is extremely important for the success of the implementation of a Lean production model in any type of company since it is oriented to the management of the human factor for the purpose of facilitating the implementation of a Lean management production model.

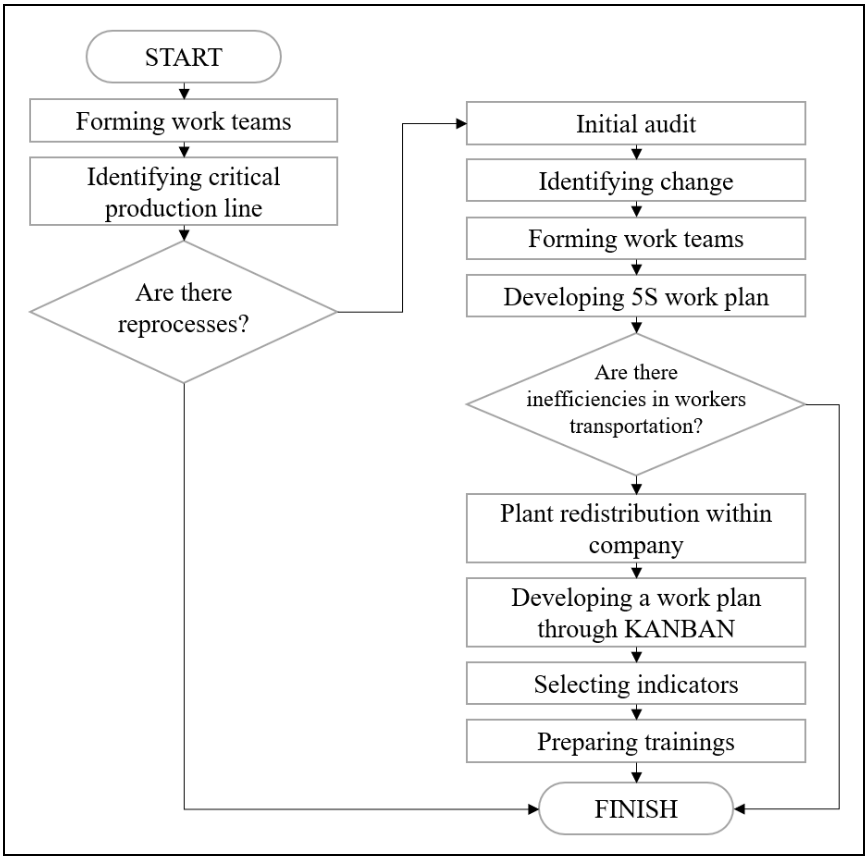

Figure 2. Process flowchart

3.4. Proposed Indicators

- **Productivity:** This indicator will help identify the number of products manufactured per hour and thus identify whether the required demand is being met.

$$Productivity = \frac{Total\ of\ products\ manufactured}{Total\ hours} \quad (1)$$

- **Efficacy:** The purpose of this indicator is to measure performance of the company area under analysis. The formula for calculation is as follows:

$$Efficacy = \left(\frac{Goal\ achieved}{Scheduled\ goal}\right) x \left(\frac{Scheduled\ Time}{Time\ Achieved}\right) x \left(\frac{Client\ Evaluation}{Total\ Evaluation}\right) \quad (2)$$

- **Efficiency:** This indicator will help us achieve the goals with minimum resources. The formula is as follows:

$$Efficiency = \left(\frac{Hours\ worked}{Hours\ available}\right) x \left(\frac{Used\ budget}{Allocated\ budget}\right) \quad (3)$$

4. Validation

4.1. Case Study

The test scenario is the manufacturing area of a textile SME. A study of operating times for each station was carried out. The proposed model will be applied to eliminate downtime. In order to do this, based on the resources of the SME, such as number of operators and number of machines, the Arena software was used to simulate the time it would take to make a batch of 100 pairs of pants. The intention is to comply on time with the scheduled batches and avoid penalties.

4.2. Current Process Simulation

The current flowchart of the path of items was prepared.

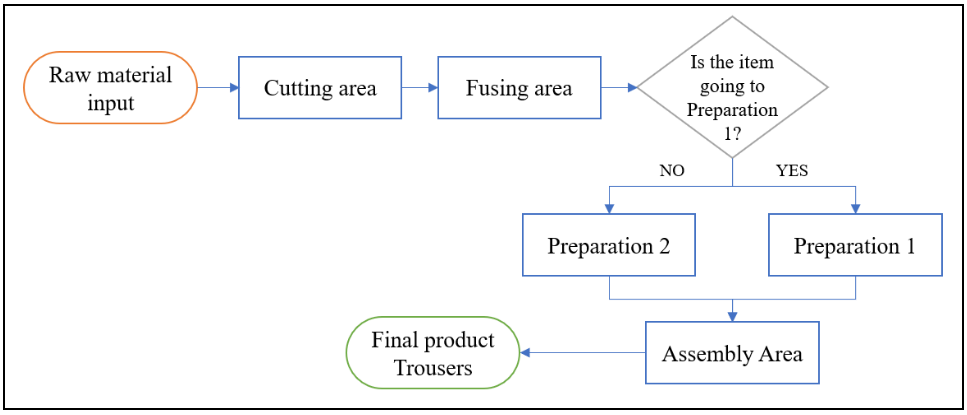

Figure 3. Current flowchart of items

The flowchart of the supervisor's path is presented to give the explanations in each station and for each batch.

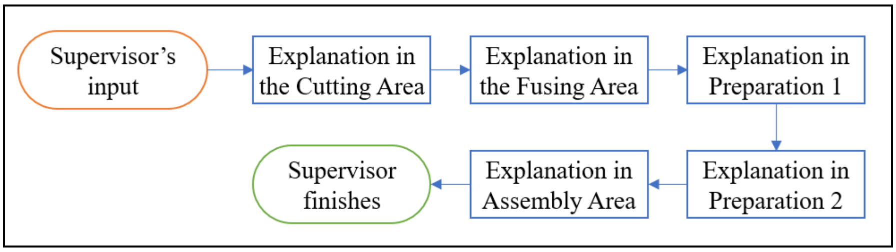

Figure 4. Flowchart of the current path of the supervisor

Using a time recorder (100 data), a PAD is carried out for the process, in which all the activities of each station are described and those that do not generate added value to the product are identified.

Table 1. Time (min) of activities per work station

Work station	Time in minutes		Total time (min/trouser)
	Activities that add value	Acitivities that do not add value	
Cutting	0.21	0.09	0.3
Fusing	0.18	0.08	0.26

Preparation 1	0.28	0.98	3.26
Preparation 2	2.65	1.14	3.79
Assembly	5.57	2.39	7.96
Total	10.88	4.66	15.5

The simulation is made in the Arena software, in which the average times recorded and the resources for each station are entered. The Arena software simulates production of a batch of 100 pairs of pants.

The following table shows a summary of the results obtained:

Table 2. Summary of results

Description	Data	Unit
Working time	8	Hours/day
Days per month	20	Days/month
Current takt time	0.97	Min/trouser
Av. Production current month	9,897	Trousers/month
Scheduled production of month	12,000	Trousers/month
Batches on time average	18	Batches
Delayed batches average	5	Batches

In one month, there is an average of five late orders. This results in the payment of penalties, which impacts profits. During 2017, 20.3% were late orders and the profit lost was 201,659 Soles. In 2018, the values for late orders and profit lost were 24.5% and 204,264 Soles, respectively.

4.3. Simulation with the Implementation of the Model Proposed

The simulated proposal considers the implementation of the 5S and Kanban Lean manufacturing tools as well as the improvement in the efficiency and productivity of the collaborators owing to change and knowledge management.

The proposed scenario eliminates the following activities:

- Explanation of the characteristics by the supervisor.
- Position of the supervisor.
- The additional time spent searching for tools and materials.
- Unnecessary motion due to disorder in the manufacturing area.

After this, the item path flowchart is as follows:

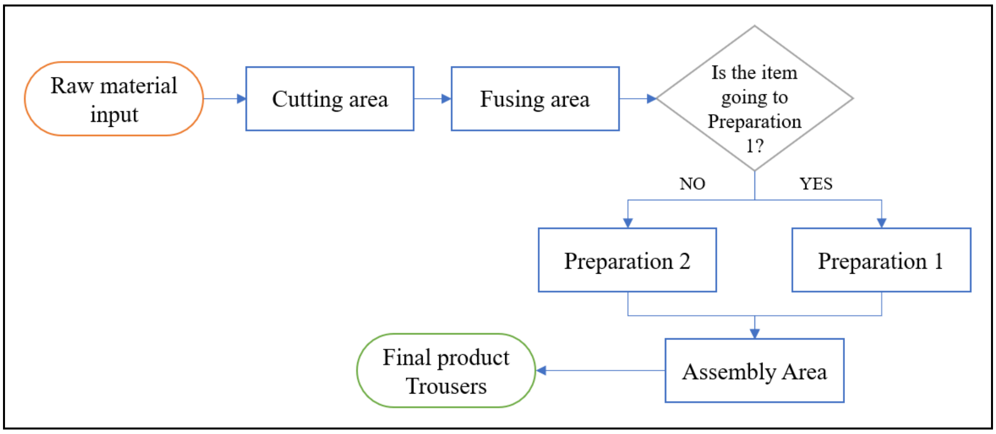

Figure 5. Proposed flowchart of the path of the items.

Although the flowchart for the items is the same, the action flow performed by the supervisor has been eliminated.

Since non-value-added activities are expected to be removed with the implementation of the proposed tools, it is suggested that activities that generate downtimes and delays are eliminated from the Process Analysis Diagram.

Moreover, after eliminating downtimes, the table looks as follows.

Table 3. Time (min) of activities per workstation

Workstation	Time in minutes		Total time (min/trouser)
	Activities that add value	Activities that do not add value	
Cutting	0.21	0.00	0.21
Fusing	0.18	0.00	0.18
Preparation 1	0.28	0.00	0.28
Preparation 2	2.65	0.00	2.65
Assembly	5.57	0.00	5.57
Total	10.88	0.00	10.88

Arena simulates the production process for 100 pairs of pants. After the simulation in Arena, the following results are obtained:

Table 4. Summary of the results of the simulated proposal

Description	Data	Unit
Working time	8	Hours/day
Days per month	20	Days/month
Current takt time	0.78	Min/trouser
Av. Production current month	12,308	Trousers/month
Scheduled production of month	12,000	Trousers/month
BATCHES ON TIME average	23	Batches
DELAYED BATCHES average	0	Batches

With the proposed model, the takt time of the pants is reduced by 20% and the quantity produced per month increases by 25%. This avoids late orders and eliminates the costs of paying penalties.

5. Conclusions

The Lean Production Management Model integrates knowledge and change management together with 5S and Kanban techniques in order to obtain better results in the implementation, taking into account the human factor as the main factor to achieve success. Productivity increased by 24.8% with respect to the productivity initially obtained, from 9,850 to 12,300 pants produced per month; further, takt time was reduced by 20%. With these results, the demand for orders will be covered and the payment of penalties for late orders will be reduced by 84%.

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