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Production Model to Increase the Rate of Order Fulfillment through the Implementation of Lean and MRP Tools in Dyeing in the Textile Sector

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Abstract. The textile sector is one of the industries with the greatest relevance and development of the Peruvian economy, however, currently customers are characterized by being increasingly demanding, which forces organizations to be more flexible to change, these changes have a great impact on small and medium-sized companies as it causes problems of non-fulfillment of orders making service levels very low. It should also be noted that it is these companies that are unaware of the importance of using continuous improvement tools, as well as those that provide little or no training to their staff as a strategy to mitigate the problem. Consequently, a literature review was carried out in order to compile production models of the textile sector to solve the problem of non-fulfillment of orders. The proposed model includes Lean Manufacturing tools, as well as the use of MRP. The present design is focused on the implementation of models executed in other companies without the need for a very large investment, or the use of the most advanced technology of today.

Keywords: Lean Manufacturing, Mrp-I, Textile Sector, Compliance Rate.

1. Introduction

The textile industry is one of those that have a greater weight and relevance in the world economy, which makes this sector one of the most influential when making a treaty or trade agreement between countries. It also represents an important source of income and jobs. In Peru, the textile and clothing sector contributes 6.4% to manufacturing GDP and generates 400,000 direct jobs and 900,000 indirectly with the agricultural, livestock, manufactured fibers, chemicals and plastics sectors. In the same way, it has an important presence in the PEA in Peru, representing 2.3% of it at the national level. Another relevant fact is that the clothing subsector is where most workers are concentrated with 76.3%, while the textile subsector concentrates 23.7%. In the same way, according to the National Superintendence of Customs and Tax Administration (SUNAT), the textile and clothing sector covers a total of 93,681 companies, most of which have 99.9% belonging to micro and small enterprises. It is important to note that the level of production, specifically in the textile sector, was decreasing, reaching a fall of 7.4% in 2019, which shows a low utilization of the production capacity of this sector. On the other hand, the level of production that was reached during the year 2020 had a contraction of 25.7% due to the coronavirus pandemic. This information allows us to know that the textile sector today is going through multiple operational problems, which does not allow an optimal development of production, so that in this way the level of competitiveness existing in the market is achieved [1]-[3].

The problem identified, according to the literature, may be due to multiple inefficiencies such as the high rate of reprocessing, a lack of planning and forecasting of demand, as well as a lack of inventory policy or priority of inputs, which results in a low effective capacity of the company. This problem was identified in another research. In an investigation for the reduction of times and the number of defective products, using Kanban and 5S tools it was possible to reduce the percentage of unfulced orders from 35.5% to 10% and the percentage of defective production and delays went from 8.14% to 2.75%. Another success story where Lean manufacturing tools such as 5S and kaizen were applied, allowed to improve the process of washing and dyeing garments and increase their capacity by 12%. Also, another research done in an SME in Peru in the

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textile sector managed to increase production efficiency from 68% to 71% by implementing the lean manufacturing philosophy to the organizational culture. The case studies mentioned show that the implementation of Lean manufacturing tools, especially SMEs in Peru, make it possible to obtain great benefits in production performance and reduction of errors during it [4]-[6].

In this context, it is clear that companies belonging to the textile sector have the need to make their production more efficient and thus be able to satisfy to a greater extent the existing market demand. For this, the case study company was chosen, since it reflects the problems of the non-ordering sector due to causes such as the high rate of reprocesses for defective products caused by a low level of efficiency in its production, as well as an inadequate supply of inputs. The reasons for the problem represent a negative economic impact of 8.3% on the profitability of the company. For this reason, to solve the problem described above. Based on this, a production improvement model was developed combining the tools of Standardized Work, MRP and Audits 5s. This model was developed based on research works that show success stories, with similar problems found in the literature reviewed and these help to solve the main problems of the sector. The present research proposes a combined model for a company dedicated to fabric dyeing. It is worth mentioning that there is not a large amount of research of companies of this type, since most of the studies are focused on companies belonging to the subsector of clothing but not that of dry cleaning. For this reason, the need arises to carry out this research so that it serves as an example of success for companies in the same field, so that in this way make SMEs competitive in the textile sector within the Peruvian market.

This scientific article is divided into seven parts, which are Introduction, State of the Art, Contribution, Validation and Discussion, conclusions and references.

2. State of Art

Companies dedicated to the textile sector in general continuously present a high rate of non-fulfillment of orders, so it is necessary to know the needs that they have in the face of this problem in order to meet the needs of customers on time and without any problem. In the same way, textile companies require a lot of labor, therefore, efficiency along with productivity depends a lot on the skills of people, as well as their behavior. Given this situation, it is extremely necessary that textile companies have a production model that allows to avoid potential failures within the production process, in order to eliminate failures or somehow minimize risks. These problems presented by most textile companies can be reduced by using lean manufacturing tools. On the other hand, the high turnover of the sector causes learning to be tedious causing problems directly to production, so the company needs to be much more efficient [7]-[11].

On the other hand, a company with little experience in the use of techniques and tools of continuous improvement does not have evidence of formal mechanisms or dynamics, the lack of this organizational culture in textile companies is one of the barriers to the implementation of an improvement proposal. Textile manufacturers globally present the same challenges, so companies are forced to reduce costs and lead times by delivering quality products to attract customers [7], [8].

The textile sector currently reports many delays in its production caused due to inefficient manufacturing processes, in a textile SME the times in manufacturing greatly delay production. In the textile industry, especially companies that depend on small batches and orders, which must adapt quickly to market changes. On the other hand, low productivity efficiency is a frequent problem in SMEs, since most show an absence of qualified personnel and increasing costs, so it is recognized that textile companies do not have a business culture regarding innovation. Given this situation, it is extremely necessary and essential to adapt a Lean production management model to the organizational culture, as well as to apply tools such as "Value Stream Mapping" and the "5's" methodology as the basis of the organizational culture of continuous improvement. In addition, textile companies must rely on standardization and repeatability during their production processes [12]-[15].

On the other hand, it is observed that there is a lack of understanding of Lean Manufacturing in SMEs in the sector. In addition, the case study can make it easier for managers and professionals to identify problems in their organizations' procedures and processes. An adequate implementation of a Lean management model

in SMEs has positive aspects since it allows companies to be more efficient, achieving with this a lower delay in production.[16], [12], [14].

In the textile industry, the inadequate management of inputs causes a loss of control in inventories, which in turn generates a shortage of stock of different materials necessary for production that prevents the continuity of this. Likewise, companies in this area incur extra charges, which could be avoided, due to the hours lost in production for this reason. For an SME in the sector, material requirements planning (MRP) is adjusted to the recurrent needs and problems that arise when making input purchase decisions, since the amount needed for a period is determined [17]-[21].

The main benefits of an MRP in the textile sector are a smoother material flow with adequate sourcing, timely order completion and improved productivity performance. In addition, with the reduction of total costs in inventories due to bad practices, it becomes more efficient in all production lines, since it means avoiding unnecessary expenses that can be higher than 50% in many companies in this area. .[18], [20], [21], [17].

Downtime in production flows in SMEs in the textile sector is a very recurrent problem that is mainly due to the absence of standardized production systems and inadequate resource planning. [22], [23]. The lean manufacturing tools used in these cases are 5S, Kaizen, standardized work and "Just in Time". Likewise, MRP is another complementary tool for inventory management that ensures the availability of raw materials and complements with the necessary quantities to avoid production stoppages.[24], [22], [25]

Following the implementation of the aforementioned tools, raw material shortages were greatly reduced, productivity at workstations was increased, downtime was reduced, the rate of defective products was reduced, and operational efficiency[22], [26]increased. The commitment of workers, from operators to senior management, is fundamental for the correct development of these good manufacturing practices, for this the training of personnel is necessary to develop criteria in making quick decisions during production.[23]–[25]

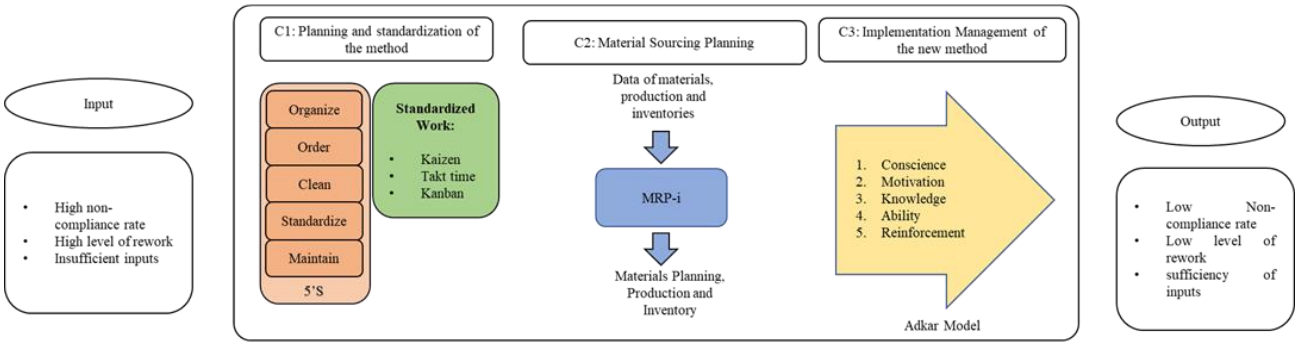

Fig. 1. Proposed model to increase the rate of the order fulfilment.

3. Contributions

3.1. Proposed Model

For the elaboration of this model, lean manufacturing tools and material supply management are combined with "MRP-i". This seeks to reduce the rate of reprocessing due to stains and fungi, as well as bad practices due to an inadequate working method and the lack of inputs during production. All the indicators mentioned above, generate lost time that makes it impossible to continue production and consequently the non-fulfilment of orders. The motivation of this research is to make it competitive in the Peruvian market and in the face of massive imports from the Asian continent, also the contribution is to ensure its correct implementation through a process of learning and commitment by all members of the organization through the Adkar model.

3.2. Model Components

- Component 1: Planning and standardization of the working method

In this first phase, the improvements to the current work model will be planned, where a diagnosis of the current model will be used by the 5'S technique. Then, the critical points that need some improvement and what the new work model would be like will be identified. Finally, it will be necessary to implement a

standardized work that allows to carry out the activities with the new method of work, for this Kaizen and Kanban techniques will be used so that it can be replicated throughout the organization.

- Component 2: Planning of supply of materials.

In this second stage, the supply of MRP-i materials will be planned, where with the help of a planning system with data collection and inventory policies, it will be possible to prioritize inputs and have an adequate forecast of demand.

- Component 3: Management of the implementation of the new working method

In this third stage, the transition of workers to the new work model will be managed. For this, the Adkar model will be used, which consists of 5 steps to have a better implementation of the changes within an organization in different areas.

3.3. Model Indicators

Non-fulfillment of orders (Ip): It is the percentage of orders that did not arrive to be completed within the period of time agreed with the client.

$$Ip = \left(\frac{Unfulfilled\ orders}{Total\ Orders}\right) x\ 100$$

Reprocesses (Re): It is the percentage in which a process is repeated due to imperfections in the final product in a dry cleaner.

$$Re = \left(\frac{Kilograms\ of\ fabric\ reprocessed}{Total\ Kilograms\ to\ Process}\right) x100$$

Audit classification P(5's): It is the ratio obtained from an audit carried out in the company.

$$P(5's) = \left(\frac{total\ score\ achieved}{Total\ Score\ reachavel}\right) x100$$

Cycle time (Ts): It is the time in which the finished product is obtained from raw material in a process. The goal is to reduce by 10% asa minimum.

$$Ts = \left(\frac{Sumatory\ of\ observed\ times}{Cycles\ in\ the\ system}\right) x100$$

4. Validation And Discussion

In this research, the use of these tools that make up the lean and MRP model will be applied in stages in the cotton fabric dyeing process in order to verify previously obtained results.

It is necessary to emphasize that the indicator of non-fulfillment of orders, for the textile industry in general, should have a value no greater than 8, so the need for an improvement in this case study is appreciated.

4.1. Initial diagnosis

The current case study shows us a high rate of non-compliance of orders of the company under study, therefore, the primary objective is to reduce the rate of non-fulfillment of orders. Currently, the company under study has a rate of 24% of orders not delivered within the established deadline. For the reduction of non-compliances, the main problems of the textile sector are addressed, which are: High level of reprocesses, Lack of inputs and unplanned stoppages.

Next, the evaluation made to the company will be shown, showing different indicators for their respective measurement and evaluation.

4.2. Validation design and verification with the initial diagnosis

To carry out the application and validation of this model, a simulation will be used in the Arena 16.1 software, in order to make the comparison between the current situation in which the company under study is located with the ideal situation of the same. First, the current situation is analyzed by collecting literary information to know the optimal levels of each KPI in the textile sector for its subsequent simulation and execution of the improvement proposal.

The figure below depicts the complete fabric dyeing system. According to this, we will proceed to compare the current indicators, what is expected and to conclude the values obtained after the simulation. This will allow us to demonstrate the effectiveness of our improvement proposal.

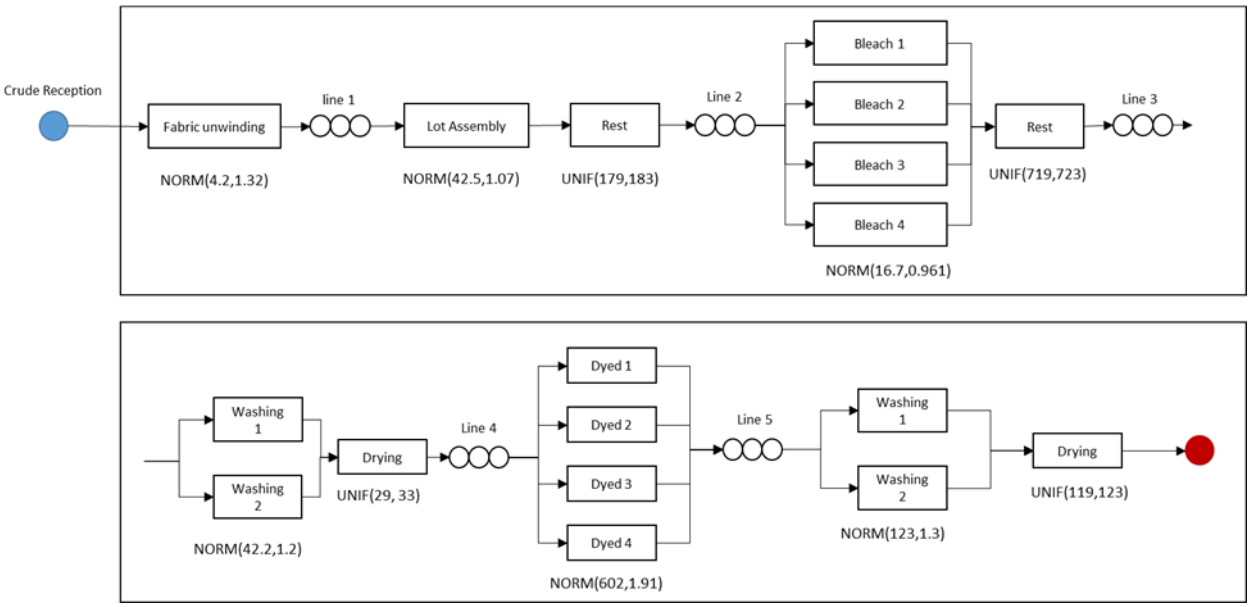

Fig. 2. System representation of improvement

4.3. Simulation of improvement proposal

The simulation began with the collection of data obtained directly from the company under study. In the same way, we proceeded to order times, obtained from each stage of the fabric dyeing process. In this way we sought to find the optimal sample size for each stage of the process and in this way obtain an adequate functioning of the simulation. For this, a confidence level of 97% and a sample error of 10% were used.

TABLE I. DISTRIBUTION OF TIMES BY PROCESS

Process	**Distribution**
Fabric unwinding	NORM(46.2, 1.32)
Assemble batch in coil	NORM(42.5, 1.07)
Rest 1	UNIF(179, 183)
Chemically bleaching	NORM(16.7, 0.961)
Rest 2	UNIF(719, 723)
wash(semi-white)	NORM(42.2, 1.2)
Dry 1	UNIF(29, 33)
dye	NORM(602, 1.91)
Wash	NORM(123, 1.3)
Dry 2	UNIF(119, 123)

The data obtained for each stage of the process was entered into the Arena 16.1 software using the Input Analyzer tool where the most appropriate distribution for each stage of the process was recognized. In this way, the following results were obtained.

The next step is proceeded to make a scheme of the process and in this way to be able to enter the parameters calculated previously with their respective distribution obtained by the Input Analyzer, is in order to show the validity of the improvement proposal model and what impact it has on the company under study after its respective implementation.

It is considered from the beginning that the project is working within the fabric dyeing production line of a textile company, which carries out the dyeing process of three types of fabric (cotton, polyester and flannel). Therefore, using the multi-product diagram method where the standard product was obtained. Therefore, we will proceed to the elaboration of our simulation based on the selected product (cotton).

After the elaboration of the model proposed above, the corresponding runs are carried out, in order to obtain the results of the scenarios before and after the implementation of our improvement proposal shown in the table shown below.

TABLE II. COMPARISON MATRIX

INDICATOR	CURRENT	OBJECTIVE	ENHANCED
Non-fulfillment of orders	24%	8.14%	13.75%
Audit Rating (%)	42.40%	85%	56.02%
% Reprocessing in dyeing	10.98%	8.14%	9.15%
Dyeing cycle time	32	29	29
Stock breakage	9.74%	8.14%	8.14%

5. Conclusions

The elaboration of the simulation allowed us to obtain positive results, which means an increase in order fulfillment to 13.75%, this allows us to recognize the importance and effectiveness of our proposal for improvement and at the same time a possible use of this in Peruvian companies in the same sector.

In the same way, the use of the lean tools used in the model allow the company to eliminate activities and waste that do not add value.

For a future study it is recommended to make a diagnosis with a greater specific focus on the loom dyeing industry since the information on this specific sector is scarce. In the same way, a larger-scale data collection must be prioritized that allows to have a lower variation in the results, less error and greater precision in the results for the elaboration of the simulation.

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