Chapter 3 Value chain diagnostic to formulate a portfolio of technological innovation projects in an automotive supplier

Capítulo 3 Diagnóstico de cadena de valor para formular una cartera de proyectos de innovación tecnológica en un proveedor automotriz

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Abstract

This chapter of the book documents an analysis of the current status of the value chain of an SME in the textile sector in Tlaxcala, provider of the automotive sector, for which the case study method is applied; Data collection is initially carried out on site, then an analysis is made of the information collected from which the key performance indicators (KPI's) of the manufacturing area are calculated. Finally, the Value Stream Mapping (VSM) method analyzes each of the processes of the value chain, evidencing areas of opportunity and designing strategic proposals for technological innovation and improvement, aimed at strengthening the business model of the company, as well as generate a portfolio of projects that can participate in national calls for the obtaining of economic funds.

Value Stream Mapping (VSM), Value chain diagnosis, Technological innovation, Automotive Sector

1. Introduction

The technical study in the development of a project is a fundamental part to decide the viability of this, because it must contain the essential elements related to the engineering of the project that is to be implemented, therefore it is important to apply a methodology that provides relevant information to identify the activities that give value to the processes. Therefore, the technical study is used to generate a portfolio of projects whenever according to one of its definitions it allows to propose and analyze the different technological options to produce the goods or services that are required, which also allows verifying the technical feasibility of each of them. This analysis identifies the equipment, machinery, raw materials and facilities necessary for the project and, therefore, the investment and operating costs required, as well as the working capital that is needed. (Rosales, 2005).

To identify the activities that most impact the technical study, a value chain diagnosis is applied because the value chain of an organization identifies the main activities that create value for customers and the related support activities. The chain also allows identifying the different costs incurred by an organization through the different activities that make up its production process, which is why it is an essential element to determine the cost structure of a company. Each activity in the value chain incurs costs and limits assets, in order to achieve its due analysis and consideration allow to improve the techno-economic efficiency of a company, a group of companies or a specific industrial sector. (Quintero, J., & Sánchez, J. 2006). Each activity in the value chain incurs costs and limits assets, in order to achieve its due analysis and consideration allow to improve the techno-economic efficiency of a company, a group of companies or a specific industrial sector. (Cayeros, Robles, & Soto, 2016).

Thus, the aim of the project is to justify the feasibility of proposals for Technological Innovation projects in an Automotive Supplier through value chain diagnosis. In general terms, it is to align the scope of the study with the economic and technological strategies of the company, to model a family of products to analyze the sequence of operations; collect key indicators from process flow diagrams, path and process graphs as background to in turn model the current and future VSM.

The development of proposals for technological innovation and continuous improvement from the Value Stream Mapping (VSM) of the manufacturing process of the product supplied to the automotive sector under a Lean Manufacturing approach allows to know how the production process is currently throughout of the value chain. (Nava, Tolamatl, Gallardo, & Calvario, 2016). Due to the trend of demand for the company's product in the automotive sector (statistics for the year 2013, according to Calvario) (Calvario, 2013). It is required to increase production volumes, and optimize the process. The presence of both national and foreign competition, forces a process of innovation, in order to achieve competitive advantages in quality, delivery times and satisfaction of the automotive sector.

The work plan contemplates 5 phases (Definition, Current Situation, Obtaining measurables, proposal of projects and technological innovation); with their respective actions and restrictions; which allow to clearly define the identification of areas of opportunity that may be feasible for the project portfolio; despite the fact that only an improvement proposal is carried out, and an analysis of the means and parameters of execution which are defined and supported by lean manufacturing tools for their execution and the VSM is mainly used to identify and graphically show the areas of opportunity.

The company finally evaluates the technological innovation proposals and aligns them with their development strategies. Regarding the methodology used, in Phase 1, the scopes and objectives aligned with company policies are defined. In Phase 2, information is collected and processed from the production line in order to analyze the current status of the company in its operations. In Phase 3, specific information is obtained so that in Phase 4 the value chain map is developed in the current status. Finally, in Phase 5, the projects presented by the HEI (Higher Education Institution) to the company are identified and proposed so that, this may select the most appropriate according to its priorities and technological strategy.

2. Theoretical Review

The quantification of risk in investment projects has been one of the central concerns of researchers and operators in finance, due to the growing need to respond to the regulations issued by national and international regulatory entities. (Bazzani & Cruz, 2008)

The Science and Technology Law (STL), in its article 1, (Official Gazette of the Federation, 2013) regulates the support that the Federal Government is obliged to grant, to promote, strengthen and develop scientific and technological research in the country, as well as to determine the legal, financial and administrative instruments, through the National Council of Science and Technology (Consejo Nacional de Ciencia y Tecnología) "CONACyT"; which, under the modality of the stimulus program for research and technological development and innovation, requires specific information on these projects to validate technical feasibility. Which refers to the availability of the necessary resources to carry out the objectives or goals indicated and is based on 3 basic aspects: operational, technical and economic. The feasibility study collects relevant data on the development of a project and based on this, the best decision is made. The success of a project is determined by the degree of feasibility that is presented in each of the three previous aspects.

Nowadays, the most of the public funds for the financing of technological projects, recognize as valid the structure that the standard NMX-GT-002-IMNC-2008 (Normalization, 2008) which is proposed for the formulation and planning of a technological project, so it is recommended for the companies to use this scheme to plan and monitor the projects.

But the tools under which the data are obtained to document each of the elements of the structure of the norm, are not mentioned again, nor suggested. Several authors handle technical study as a key tool to document or support projects.

The objective of the technical study is to provide both the technical information of the means of production and the structure of investments, costs and income, which will be used in the evaluation of the project (Morales C., 2010).

But once again the tools to obtain the parameters are not mentioned or suggested.

Lean manufacturing also called lean production is a work philosophy, under the approach of continuous improvement and optimization of a production or service system, by fulfillment of its objective which is the reduction of waste of all kinds, times, defective products, transportation and work by teams and people. It is not a static or radical philosophy that moves away from what is already known, rather its novelty consists of the combination of different elements, techniques, applications and improvements arising in the elaboration of the work.

Lean manufacturing has its origin in the Just in Time (JIT) production system, which was developed in the 50s by Toyota. Over the years, this philosophy has been modified and converted into the paradigm of productivity improvement systems associated with industrial excellence (Rojas & Gisbert, 2017).

Companies that work according to Lean Manufacturing principles, systematically seek to know what the customer recognizes as added value and is willing to pay for it, while eliminating those operations of the process that do not generate value.

The objective of Lean Manufacturing is to propose improvements in the processes through the analysis of the value chain, and the implementation of quality tools and macro indicators (Rueda, 2007). The OEE is included in the indicators used (Sistems OEE, 2018). This indicator measures the efficiency of industrial machinery, and is used as a key tool within the culture of continuous improvement. Its acronyms correspond to the term "Overall Equipment Effectiveness". It was used for the first time by Seiichi Nakajima, the founder of TPM: Total Productive Maintenance, as the fundamental measurement tool to know the productive performance of industrial machinery. The challenge was even greater when it created a sense of joint responsibility among machine operators and maintenance managers to work on continuous improvement and optimize Overall Equipment Effectiveness (OEE).

Another indicator that was used to balance the line and establish projects is the Takt Time (Ortiz, 2006). It is the time in which a unit of product must be obtained. It is a well-known term in manufacturing which is used to establish the time it takes to complete a unit to meet the demand.

The improvements presented by the analysis of these indicators can be seen crystallized in research projects and/or technological development and innovation. In addition to the fact that Lean Manufacturing grants the continuous improvement of a production system, the importance of using this method, and its tools, is due to the fact that it generates all the dynamics and context to develop; stages that make up a feasible project, an operational guide to guide the preparation of each of the parties; the technique and the instrument for the collection of information. In the same way, it allows establishing the conformation of a discrepancy analysis instrument and feasibility analysis. Culminating with the last two stages of a feasible project, the formulation of proposals and recommendations for a successful execution of the proposals that make up a portfolio of research projects and/or technological development and innovation with the plus of responding to the regulations emanating from national and international regulatory entities.

3. Methodology

The value chain concept of a company shows the set of activities and interlaced functions that are carried out internally. The chain begins with the supply of raw material and continues throughout the production of parts and components, manufacturing and assembly, wholesale distribution and in such a way until reaching the final user of the product or service (Quintero y Sánchez, 2006).

General Objectives

Justify the technical feasibility of proposals for Technological Innovation projects in an Automotive Supplier through value chain diagnosis.

Scope

The case covers all the areas involved in the manufacture of the products, and the proposal to identify areas of opportunity through the main use of the VSM, which is indispensable for the identification of waste, showing an overview of the current situation of the company and taking into account the importance that the client has; then, as already identified proposals, specific projects will be recommended to correct and / or improve the current situation maintained by the company.

Regarding the technical study, only the technical part will be emphasized without taking into account allusive data to the economic and operative part, as well as the justification of economic amounts related to the projects selected by the company and proposed in the CONACyT call.

The methodology used in the field followed the following structure to characterize the company:

Phases

Phase 1. Definition

a. Scope
b. Limitations.
c. Justification.

d. Objective.

Phase 2. Current situation

a. Product family.
b. Diagram of flow.
c. Layout.
d. Graphic of distances.
e. Diagram de processes.
f. Waste identification.

Phase 3. Obtención de medibles

a. Shifts by department.
b. Areas by department.
c. Cycle times by areas.
d. Quality Load Factor by area (QLF).
e. Availability index of each area.
f. Leveling of the required demand per day.
g. Inventory of raw material**.**

Phase 4. VSM Current status

a. VSM Current Status
b. Takt Time (TT).
c. Cycle Time (CT).
d. Graphic TT – CT
e. Overall Equipment Effectiveness (OEE).

Phase 5. Project proposal and technological innovation

a. Project to guarantee the uniformity of the thread.
b. Project to improve the flow of information and materials through the elimination of waste generated in the production line
c. Results report

4. Development

In Mexico, the automotive industry has developed important productive linkages with the glass, steel, iron, rubber, plastic, aluminum and textile industries (Secretaría de Economía, 2012), with which it has become an important driver of manufacturing and economic activity in the municipalities and regions where it is located (Carbajal, De Jesús, & Mejía, 2016).

The case study of the present investigation corresponds to a company in the textile sector supplier for the automotive sector located in the area of influence of the HEIs (Higher Education Institution). This company is classified within sector 313: Manufacture of textile inputs and textile finishing that groups together economic units dedicated mainly to the preparation and spinning of natural textile fibers; to the manufacture of threads and fabrics, and to the finishing and coating of textiles. To develop the project, a work plan was prepared that includes 5 phases, which were applied as follows:

Phase 1. Definition

The company needs to optimize its process, to increase the production volumes, of its most demanded product by the client, representing almost 70% of the volume of the total production. It is important to emphasize this because, due to the emergence of new competitors from both the region and foreigners, the production process must be known, to make innovation and continuous improvement, and increase the production volumes of its products, allowing to achieve advantages competitive, as well as, differentiate from the competition, making sure not to lose quality, improve delivery times and customer satisfaction.

Scope

For the elaboration of the technical analysis and the proposal of technological innovation project portfolio, the tools of Lean Manufacturing (VSM, OEE, Takt Time, CT, family of products) will be used in order to know the current situation of the company through the identification of areas of opportunity, covering all the productive spaces in the manufacture of the family of products with a vision oriented to the client.

Justification

This study will allow the company to know how its production process is really working, identify the critical points, and recommend pertinent projects to remedy the problems detected under this analysis, allowing to make its production line more efficient by increasing its productivity and competitiveness.

General Objectives

Justify the technical feasibility of proposals for Technological Innovation projects through value chain diagnosis.

Specific objectives

1. Diagnose the process of the company through the value chain.
2. Prepare portfolio of technological innovation projects.
3. Analyze technical feasibility and feasibility of technological innovation project portfolio
4. Participate with technological innovation projects in the stimulus program for technological innovation of CONACyT.

Phase 2. Current situation

The textile, yarn and finishing company has two large production areas; spinning for the manufacture of the yarns and dyeing for the finishing and dyeing of the same, has a wide variety of products, among which are mainly yarn for the automotive sector, being these widely demanded, and therefore have considerable volumes of production.

Due to the appearance of new competitors in the region, both national and foreign, the company has seen the need to be more competitive with the products it offers and to achieve this it has been forced to reduce its production costs to compensate the utility and remain in the market, making sure not to lose quality in the products and the attention of their customers.

In this way it has been chosen to make use of tools, to diagnose optimize and / or improve the resources available for the manufacture of their products. For this project the VSM is used as the main tool, in order to identify and graphically show where the main waste that reduces the productivity of the company is found, and for this it is essential to establish in the first instance a family of products that represents the essence of the business.

Product family

It is a product and its variants that pass through common equipment and similar stages of process before being delivered to the customer. The importance of product families for lean thinkers is that in the value flow maps, they are analyzed considering them as units, from the farthest stage downstream to just before being delivered to the client.

Note that product families can be defined from the perspective of any customer along an extended value stream, ranging from the last customer (the final customer) to intermediate customers within the production process (Marchwinski and Shook, 2008).

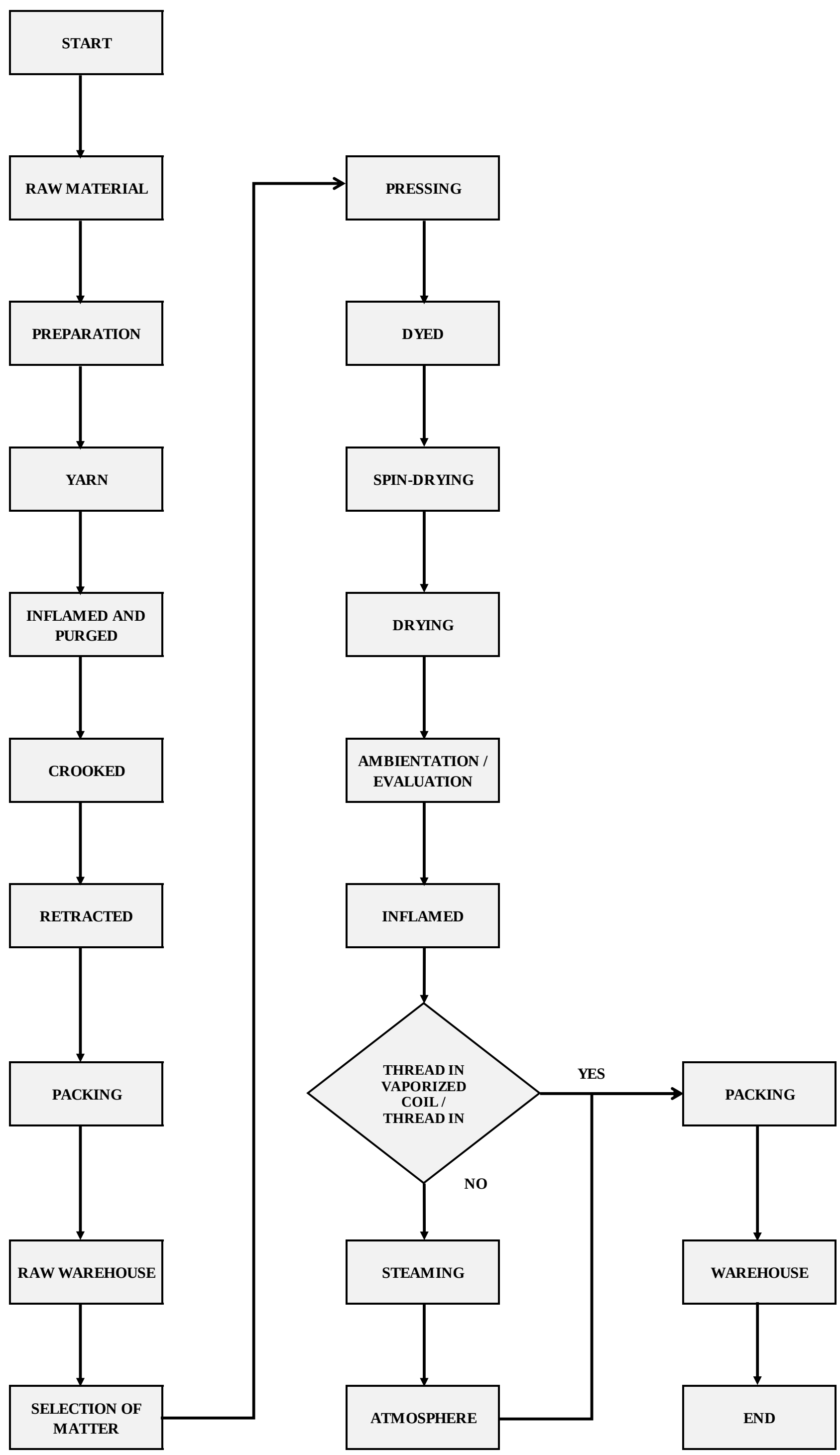
In the case of this company, there are dozens of products, 28 of which are the most commercial, but only 4 of these represent considerable volumes. 3 of these present periodicity of sale, and only 1 represents almost 70% of the volume of total production, which is why they are considered as a family of products called the parent line.

If an evaluation of production volume and manufacturing process is made, it is observed that this project will cover 92% of the production generated by the company.

Diagram of flow

A general flow diagram (figure 3.1) of the manufacture of the matrix line is elaborated in order to know the different stages of the process (Miller, Pawloski, & Standridge, 2010).

Figure 3.1 Diagram of flow of the manufacturing process



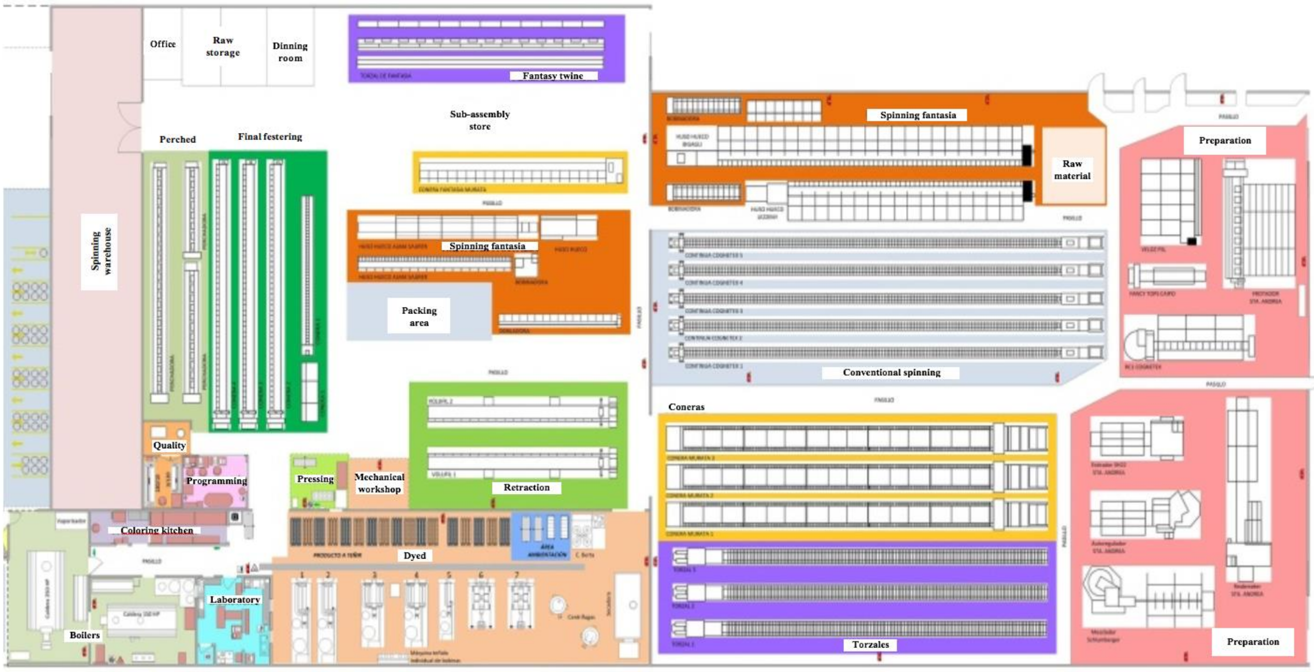
Source: Information obtained from the survey

The diagram provides an overview of the production process, since it arrives as a raw material, until it is taken to the finished product warehouse (Krajewski & Malhotra, 2013).

Layout - travel diagram

Another tool used is the route diagram (figure 3.3) which is obtained through the layout of the company (figure 3.2), where each of the areas of each production department is identified (Pérez, 2016).

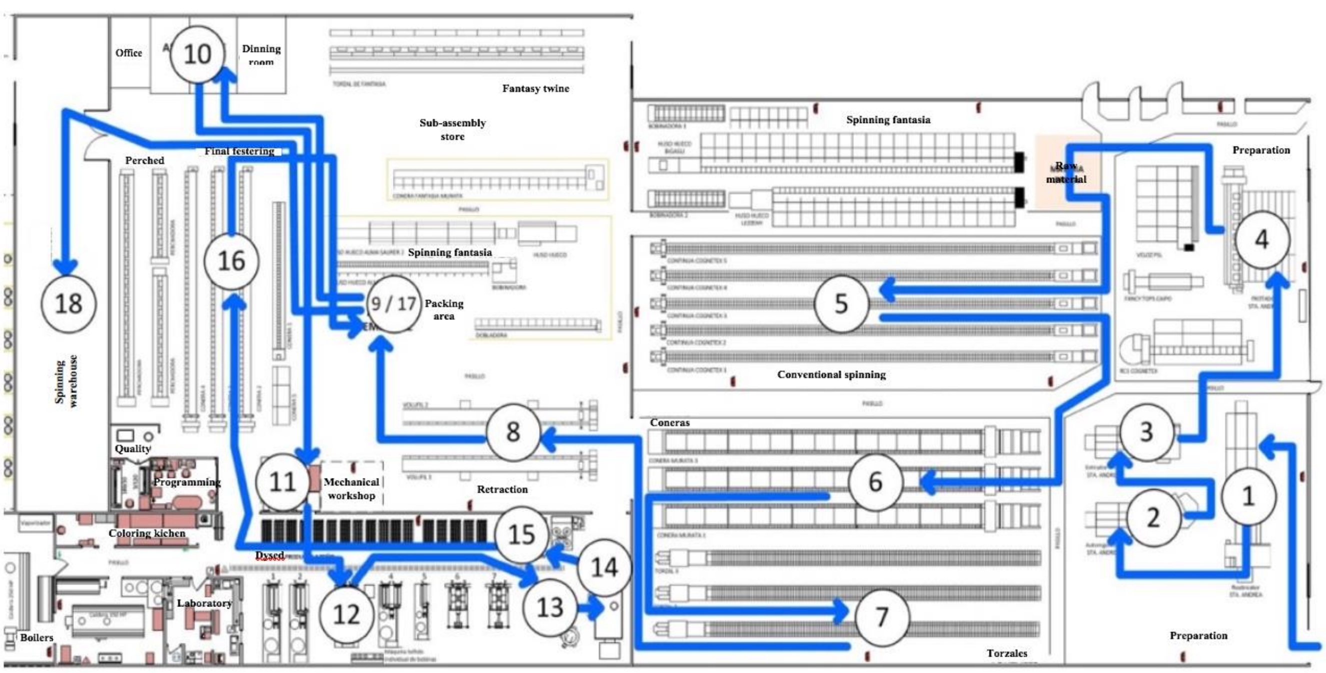
Figure 3.2 Layout of the Company



Source: Provided by the company

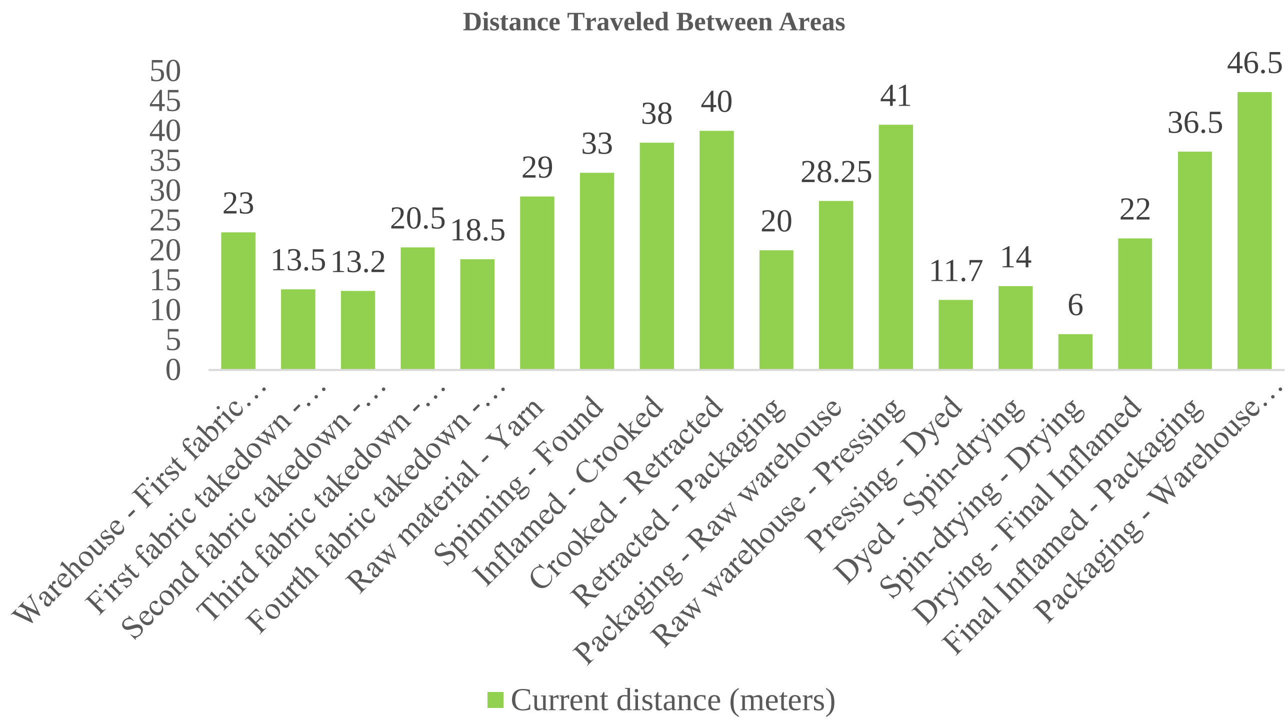
For the case of the production process of the parent line, we have the following process trajectory (figure 3.3). As can be seen, in the route diagram, the location of the machinery is not correct and shows how it was adapted the company to the changes as a result of its growth. One of the waste that takes greater relevance is the transport, and consequently the one of movement on the part of the operator, when taking or bringing material to his station of work. The distances covered by this line can be seen in graphic 3.1.

Figure 3.3 Layout with stroke of the process



Source: Information obtained in the field

Graphic 3.1 Distances traveled from the process by area



Source: Information obtained in the field

Through this information the distances traveled between each area of the production line are obtained with a total traveled distance of 454.65 meters.

Diagram of process flow

A process flow diagram is prepared to know the estimated real time of production, based on real, theoretical and historical production data, allowing to identify at the same time the different wastes that arise along the entire production line, manifesting some observations that are considered critical to devise the best plan and give the best solution (Niebel & Freivalds, 2014).

Figure 3.4 Diagram of process flow

Resumen de Actividades			
Activity type		**Syeps No.**	**Times involved**
○	Process	15	2787.4
⇨	Transfer	18	509
□	Inspection	4	0
D	Delay	1	600
▽	Warehouse	4	0
Distance traveled: ____454.65___ Mts.			
Time value (V): 2782 No time value (NV): 1114			
VA Indexe = V / (**V+NV) =			**71%**

Details of the state method	Present / Proposed	Process	Transfer	Inspection	Delay	Warehouse	Time (sec) V	Time (sec) NV	Distance moved (meters)	Amount of lot	production	Transportation	Movements	Wait	Reworks	Warehouse	Defects	Comments
Raw material warehouse		○	⇨	□	D	▼								X				The availability of raw material, or first quality, is not always ensured.
Raw material warehouse		○	➡	□	D	▽		26	23	8 pacas		X		X			X	When there is no availability of raw material, the machines are stopped, or the machine does not work and it is sent to the second machine.
First fabric takedown		●	⇨	□	D	▽	750											They have maintenance problems and adjust the machines
Quality test		○	⇨	■	D	▽												Every time a test does not pass, the machine must be readjusted
Transport to hairstyle and fabric takedown		○	➡	□	D	▽		14	13.5	7 boats		X						
Hairstyle and fabric takedown		●	⇨	□	D	▽	750						X	X			X	Frequently the machine is misadjusted, therefore adjustments have to be made, time is lost and quality problems exist.
Quality test		○	⇨	■	D	▽												
Transportation to second fabric takedown		○	➡	□	D	▽		14	13.2	8 boats (4 per boat)			X					
Second fabric takedown		●	⇨	□	D	▽	375						X	X			X	Frequently there are faults in the machine, they are readjusted and there are lost time
Quality test		○	⇨	■	D	▽												
Transportation to third fabric takedown		○	➡	□	D	▽		23	20.5	32 boats (2 per coil)		X	X					The machine is at a considerable distance from the previous machine.
Third fabric takedown		●	⇨	□	D	▽	68.18					X	X	X		X	X	By not using quality raw material, the cycle time is raised, because the machine has to be stopped, more movements are generated when fixing the defects during the process.
Transport to raw material		○	➡	□	D	▽		20	18.5	16 coils		X						
Raw material warehouse		○	⇨	□	D	▼					X	X	X	X		X		This warehouse is not controlled, therefore the aforementioned waste is generated
Transportation to yarn		○	➡	□	D	▽		32	29	352 coils		X	X					
Yarn		●	⇨	□	D	▽	16.48				X		X	X		X	X	There are 3 machines adjusted to the process, but quality raw material is not insured, therefore there is a high defect index, and scrap, in addition to not having a good production control
Quality test		○	⇨	■	D	▽												
Transportation to Inflamed		○	➡	□	D	▽		36	33	704 taps		X						
Inflamed		●	⇨	□	D	▽	44.4						X	X			X	There are 3 machines of festering in the same capacity, although they do not work 100%, because there is no excellent maintenance
Transportation to torzal		○	➡	□	D	▽		42	38	60 cones		X	X	X				Since 80% of the racks do not work, material availability is not guaranteed for the next operation.
Crooked		●	⇨	□	D	▽	289.57					X	X	X				Frequently there are problems with torzales, they do not assure availability of matter to the next operation, they generate delays, because there is no material
Transportation to retracted		○	➡	□	D	▽		44	40	115 cones (2 per cone)		X	X	X				No material availability
Retracted		●	⇨	□	D	▽	42.42							X	X		X	There are waits for not having material, there is no good flow and when they are not properly adjusted the machines are incurred to rework
Transportation to packaging		○	➡	□	D	▽		22	20	36 moff or 36 coils		X						
Raw product packaging		●	⇨	□	D	▽		5.35					X					
Transportation to raw warehouse		○	➡	□	D	▽		34	28.25	12 cones / 14 moff		X						When urgent orders are sent to another warehouse for processing.
Raw product warehouse		○	⇨	□	D	▼						X	X			X		The warehouse is at a considerable distance taking into account the trajectory that it carries out from the previous operation to the next operation
Pressed transport		○	➡	□	D	▽		45	41	1 car			X	X				
Pressing		●	⇨	□	D	▽	17.5						X	X		X		When in moff, more adjustment movements are made, in thick threads it is possible to press manually, than in thinner threads.
Transportation to dyed		○	➡	□	D	▽		16	11.7	12 coils or 14 moff in each cane		X						There is a controlled warehouse, which feeds the dyed machines.
Dyed		○	➡	□	D	▽	210					X			X		X	The PLCs are not in good condition, and some controls or parameters no longer work, they are available only in Italian, only one operator / shift is trained to control the machines. There are problems of mixing control, maintenance, and temperature.
Drainning		○	⇨	□	◗	▽		600		12 bob or 14 moff per cane		X		X				Drained from canes
Transport to spin-drying		○	➡	□	D	▽		16	14	1 trolley cart		X		X		X		
Spin-drying		●	⇨	□	D	▽	60							X				9 minutes in Berta / 1 hour in the pot (30 minutes spin-drying and 30 minutes of stoppage). The Berta spin-drying machine will be replaced with a higher capacity one.
Transportation to dryer		○	➡	□	D	▽		8	6	120 coils / 144 moff per cart		X	X					
Drying and ambience		○	➡	□	D	▽	22.5					X		X			X	If the parameters are not good on machinery or the thread to dry has defects, when leaving this operation the consequences are seen, Even after having left the dryer should be set, to dry almost completely.
Transportation to final Inflamed		○	➡	□	D	▽		25	22	1 needle cart 2		X		X				The bars of bars, are difficult to transport because they are heavy.
Final Inflamed		●	⇨	□	D	▽	56						X					There are maintenance problems with the machines, they do not always work at the same speeds.
Transport to finished product packaging		○	➡	□	D	▽		40	36.5	1 boat		X						
Packaging finished product		●	⇨	□	D	▽	80											Pack of 12 and 15 pieces
Transportation warehouse finished product		○	➡	□	D	▽		52	46.5	1 car		X						
Finished product warehouse		○	➡	□	D	▽										X		Finished product warehouse too big.
	Total	15	18	5	1	4	2782	1114.4	454.65		** V + NV = Lead Time			3,896.40				

Source: Information obtained in the field

In the process flow diagram (figure 3.4), waste that reduces production within the plant, which in this case is 29%, was identified; if it is taken into account that the value added index is 71%, although it is important to mention that the process operations are theoretical since there are always problems of adjustment in the machinery, and in some cases it was not possible to corroborate the times because They differ too much, being these high; therefore the representative sample becomes numerous and takes time to obtain the cycles to define a standard, therefore that 29% only serves as a reference although in advance it can be said with certainty that this indicator is well above this value.

There are also several problems with the supply of raw material, since this does not arrive at the time it was requested, causing delays in production, waiting to increase the dead time of the affected stations, or when it is possible to generate inventory to meet the demand. On the other hand, maintenance problems are also evident, since there is no good management of the same, there is no preventive maintenance except in some cases where machinery is checked before starting it, although it is not always carried out.

Fase 3 Obtaining measurables

Information about the company

The company has a competitive advantage to offer a wide range of products, so it is only decided to analyze the matrix line previously selected for this purpose. Information is needed on the work days for which the company has personnel divided into three shifts, which work according to the production demand of their areas, that is to say that there are cases in which only personnel of some shift work in an area already either spinning and / or dry-cleaning (low seasons), or the whole plant works the three shifts from Monday to Sunday (high seasons). The hours of entry and exit respectively for each shift are from 7:00 a.m. to 3:00 p.m., 3:00 p.m. to 11:00 p.m. and from 11:00 p.m. to 7:00 a.m.

Information about the processes

The company has two production departments, spinning (yarn manufacturing process), and dry-cleaning (dyeing and finishing process). Table 3.1 shows each one of the departments and their respective area in charge, in total there are 10 stations for the main line, and for the production line the following order is had.

Table 3.1 Departments and areas of the manufacturing process

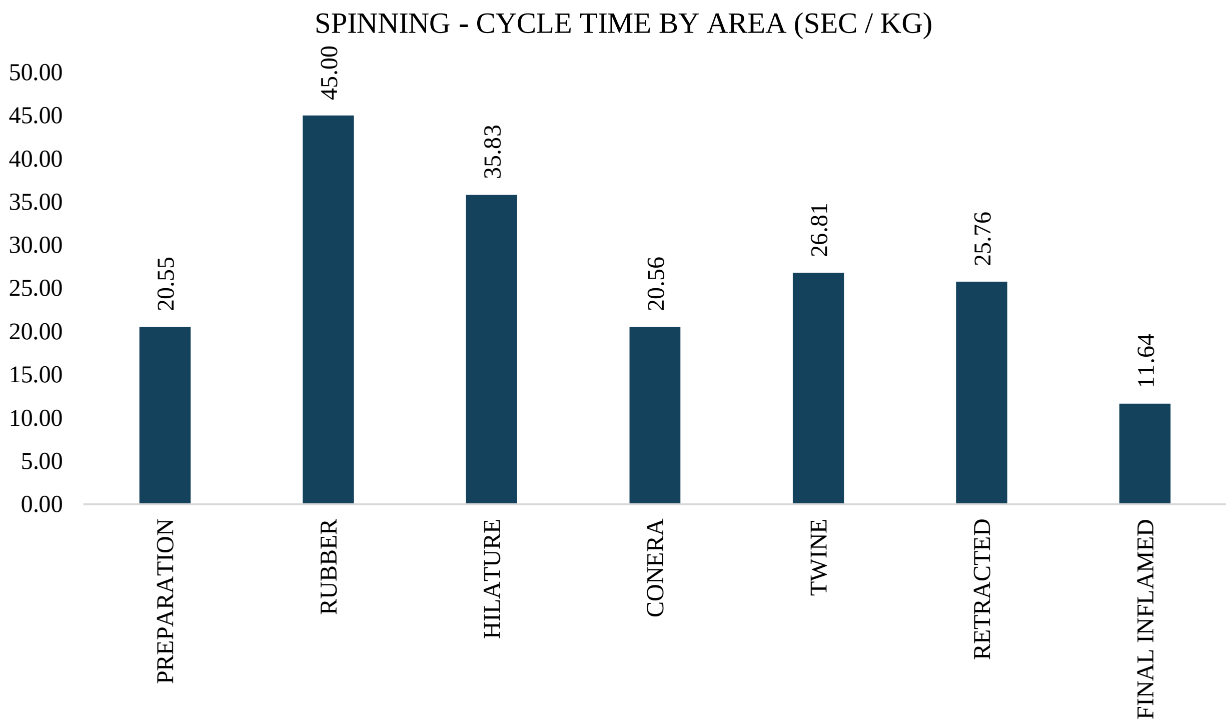
Department	Area
Spinning	Preparation (1,2,3, steps)
Spinning	Shoe
Spinning	Continuous
Spinning	Coneras
Spinning	Torzales
Spinning	Volufiles and raw packaging
Dry cleaner	Pressing
Dry cleaner	Had
Dry cleaner	Centrifuged and dried
Spinning	Reencounter and packaging

Source: Provided by the company

Spinning and dry cleaning cycle times

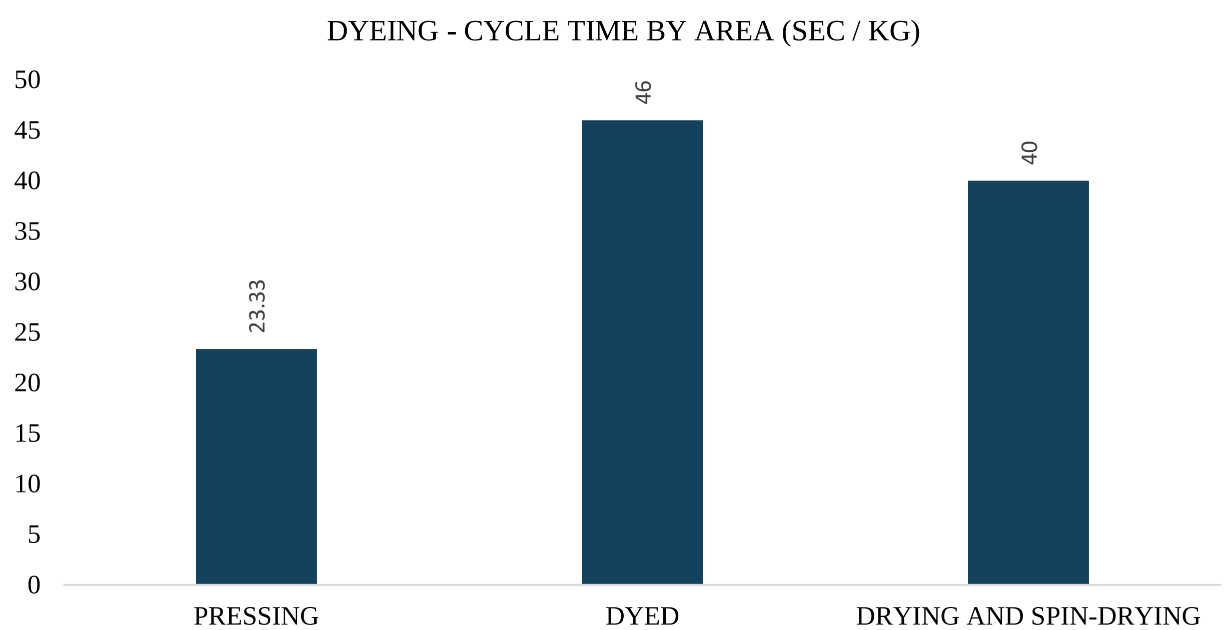
The cycle times of each of the areas were determined in order to know the manufacturing times for the matrix line, the following graphs show the cycle times in sec / kg that are needed to process one kilogram of material, in each area of spinning (graphic 3.2), and in the same way for the areas of dry-cleaning (graphic 3.3), press (pressing), Obem 1,2,4,5,7 (dyed), pot 1 and 2 (centrifuged) and boni & bulgarelli (drying).

Graphic 3.2 Spin cycle times



Source: Information obtained in the field

Graphic 3.3 Drycleaning cycle time



Source: Information obtained in the field

As in the process you have different machine capacities or you have more than one you get the real cycle time of each area, obtaining an average of all the machinery times and dividing by the amount of available machines, for the case of Different machines take the one that generated more time, given that it is the maximum speed that each area can work (Gutiérrez & De la Vara, 2013).

Determination of the quality load factor (QLF)

A sample of a week is taken into account, to collect production data, and to know how the production line really was, it should be noted that in recent months sales have declined and therefore only allowed to know the status of scrap and rework.

There is scrap concentrate and rework throughout the line which are obtained from the summary of each work station (Gutiérrez, 2014). Here you can see their respective percentage in each area and the total in the line (table 3.2).

One of the expressions for calculating the QLF is:

$$QLF = 1 + S + R \quad (1)$$

Where:
S = Scrap generated along the production line
R = Rework generated along the production line

Table 3.2 Scrap and rework indexes in the production line

Scrap Indices and Production Line Rework	
Area	**%**
Preparation	1.4%
Shoe	1.2%
Yarn	1.68%
Found	1.34%
Distorted	1.00%
Retracted and Packing	0.10%
Pressing	1.10%
Spinning and Drying	1.00%
Reencountered	1.50%
Scrap Index	10.32%
Dyeing Rework	29.41%
Q L F Process	1.3973

Source: Information obtained in the field

As the rework in dyeing is reprocessed within the line, it is considered:

Rework in dyeing equal to the inverse of the FTQ where FTQ is firts time quality for its acronym in English, then Rework in dyeing = 1 / 0.034 (considering 3.4% as quality at the first of the dyeing process) ie the rework of the dyeing department acquires a value of 29.41%. It is necessary to emphasize that the total scrap levels of 10.32% in the remaining departments and rework of 29.41% in the dyeing department are very high, giving a total quality load factor of 1.3973; waste that the company must absorb due to its low productivity. As the dyeing department was detected as an area of opportunity and could offer projects

Determination of availability

One of the most important problems in the company is the discipline to control the dead time (Kalpakjian and Schmid, 2014). In each of its areas, which did not have real and true information about the times when the machines stopped working as well as the specific causes that caused the unscheduled stoppages, however, detailed information about the volumes was available. of production as well as specific cycle times previously determined for each of the machines, so we proceeded to calculate the theoretical production volumes of each machine and compare them with the actual production volumes resulting in the difference in volume of production that the machines stopped producing for various reasons not foreseen, this difference was divided with respect to the volume of theoretical production throwing the index of dead time that each of the machines generated and the difference of 100% with respect to the time index dead determines the operational availability of each Manufacturing area (Bernstein, 2008).

There are different nomenclatures to describe the general calculation of operational availability (DO), for this reason and with the aim of avoiding controversies, it is recommended to use the following equation set out in the UNE-EN 15341 standard: 2007 (Norma, 2008).

$$D_O = \frac{Availability\ time\ achieved\ during\ the\ required\ time}{Required\ time} * 100 \quad (2)$$

Showing the results obtained in table 3.3.

Table 3.3 Availability of the areas of the production line

Production Line Availability Index	
Area	**%**
Preparation	99%
Shoe	92%
Yarn	98%
Found	94%
Distorted	99%
Retracted and Packaging	88%
Pressing	92%
Had	100%
Spinning and Drying	95%
Reencountered	97%
Online Availability Index	61.97%
Dead Time Index	38.03%

Source: Information obtained in the field

As the production process designed for the manufacture of the matrix line is a linear process and taking into account that the product of the availabilities of each area shows the availability of the system, it is observed that the production line of 100% of the available time with that account for the realization of its products only 61.97% is justified with production volume and the rest that represents 38.03% is the downtime that the line generates derived its multiple work stoppages and problems that continuously face the production process.

Determining the demand

To determine the speed at which the plant operates, we proceed to obtain historical production data for the January-June period, both for spinning and dry-cleaning, are considered in percentage terms to emphasize the production levels, taking 100% production that is greater, in the case of dry cleaning that has an average production of 41,831.12 kg per month (Table 3.4).

The level production per day of the plant is obtained, considering that they work on average 27 days a month, therefore, calculating 1549.30 kg / day.

Table 3.4 Level production data

41,831.12	Monthly production in kilos.
27	Days of production month.
1,549.30	Daily production (kg / day).
0.8	Kilograms per cone.
1,937	Cones per day.

Source: Information obtained in the field

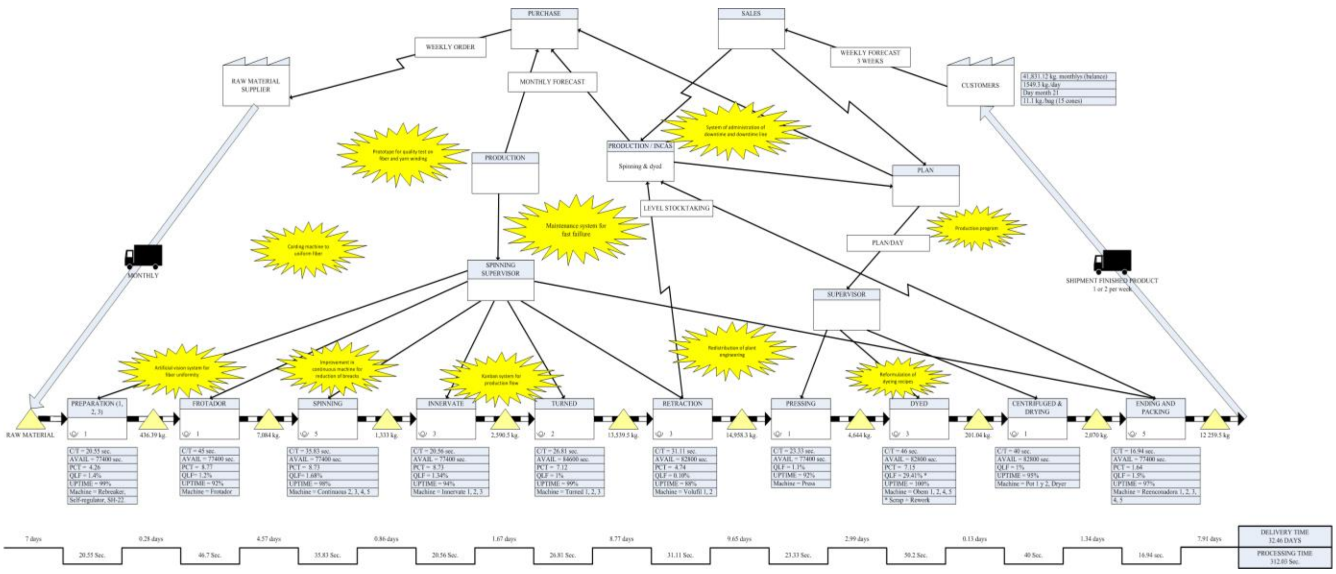
Raw material inventory

The inventory levels of each area are determined, as well as the warehouse of raw material and finished product in order to know the amount of time represented by each volume of material accumulated in each area, these inventories being the product of the planning of production and In the way in which the company manages such inventories, it should be noted that the company makes raw material requisitions every month, in which it is indicated in a disaggregated manner the one required in each week. (Valencia y Díaz, 2015).

With all this information collected and analyzed, the value chain is mapped to have a more clear vision of the way in which the company maintains its operations and how it feeds the information with each one of its respective areas (figure 3.5).

Phase 4 VSM Current Status

Figure 3.5 Current status value chain map



Source: Information obtained in the field

As can be seen in the VSM (figure 3.5), the production line involves various processes, including physical and chemical processes that allow obtaining the texture of a final thread.

The company produces in a push system, that is, the first workstation must produce to feed the next and so on to keep all other processes operating, although sometimes it is the case, where between operations if there is synchronization of time of production, but it can not be said that there is a continuous flow as such, because the parameters to ensure the flow of production are not well defined (Cuatrecasas, 2012).

It is also possible to observe information exchange between several people within the operative process, which sometimes causes confusion, incomplete information or even forgetting, since the information flows from different sides, because in addition there are not always those information channels, in Sometimes there are more ways or just the opposite, they do not happen, this channeling of information can be observed in the following VSM.

As for raw material, it is not always assured its delivery on time, there are cases in which a certain amount arrives and then another, or arrives but not another, which is also essential to start production, in this way when possible do inventory, it is done and when not, it is resorted to stopping part of the line, or in extreme cases to stop a shift.

If we mention the human resource, we do not have a record of the errors that are committed to evaluate them and put a solution or has not implemented tools to define what is the root cause of these problems.

Determination of Takt Time, PCT and OEE

From the information displayed in the VSM, the Takt Time, PCT and OEE indicators are calculated, in order to have a clearer idea of the true situation in which the company is located. Information about total time per shift is added; as starting, food, other (personnel needs) and term, table 3.5 shows the times and the calculation of Takt Time and PCT.

Table 3.5 Calculation of TT-PCT

Total requirements	1549.30	Kg/day		
	1st shift	2nd turn	3rd shift	TOTAL
Turn time (seconds)	28800	28800	28800	86400
Effective seconds				0
Start / End	600	600	600	1800
Meal	1800	1800	1800	5400
Others	600	600	600	1800
Planned dead time	0	0	0	0
Scheduled run time (sec)	25800	25800	25800	77400
Takt time = Scheduled run time / Total requirements (seg/pza)				**49.96**

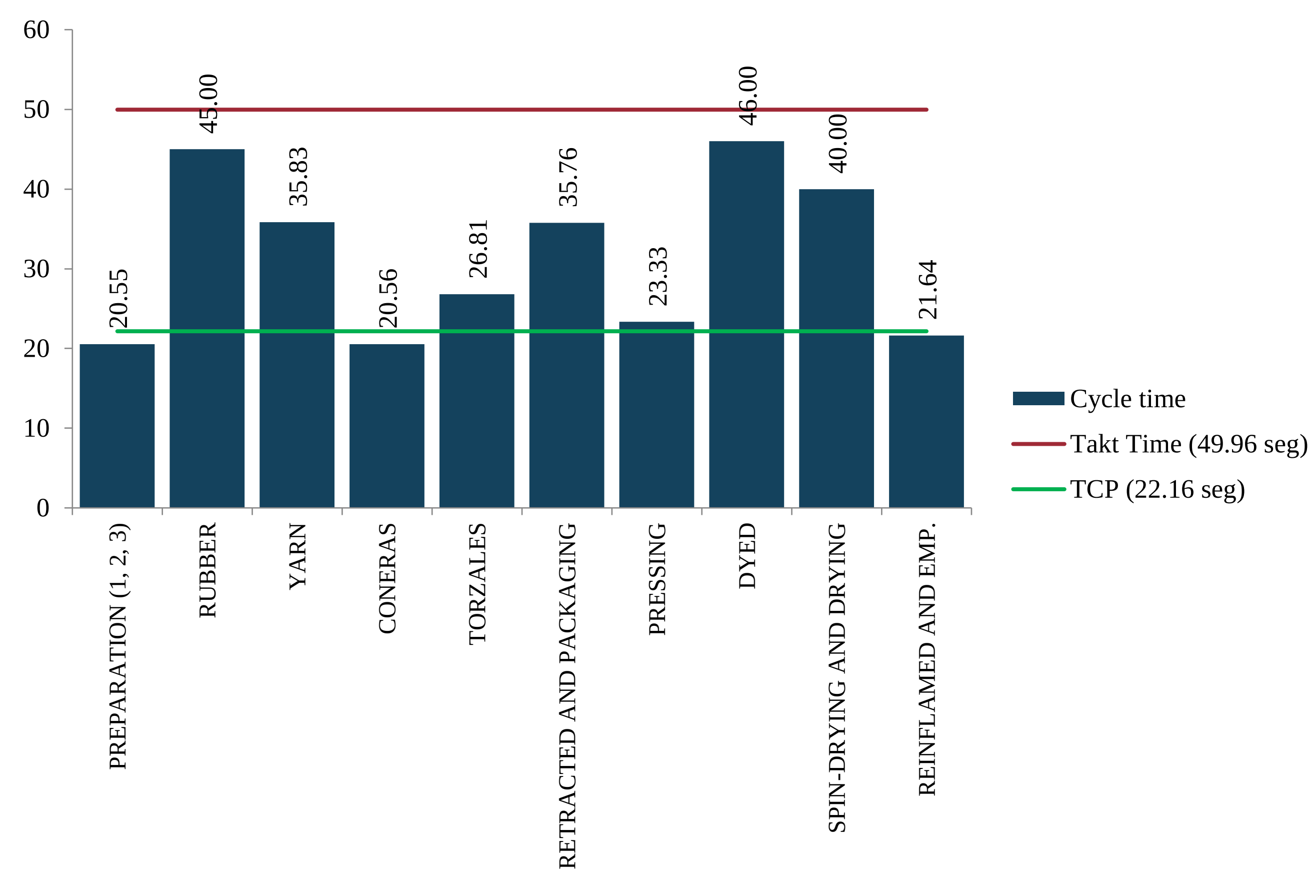
Operational availability	
Dead time (seconds)	29436
Change time (seconds)	0
Operational availability = Actual run time / scheduled run time	61.97%

Planned Cycle Time	
%scrap	10.32%
% rework	29.41%
Others:	
Quality load factor	1.397
PCT	**22.16**

Information of change times (changes, loading of material, etc.) is added. Average percentages of rework, scrap, others and average daily production, obtained from the production reports, in the same way the theoretical production is placed.

In the format there are shaded boxes of yellow and blue colors; the yellow (total requirements) is presented automatically from the leveled production, the blue ones are filled manually. Takt Time can be defined as the speed at which the customer consumes the finished product (Hobbs, 2004). Therefore, in the production line of the parent line is 49.96 sec / kg, in the same way the PCT is observed, which indicates the speed with which the line must operate to meet the demand, which is of 22.16 sec / kg. (Graph 3.4), this means that to meet the demand must be produced faster and therefore the company must assume the waste generated, otherwise if the PCT were the same as the Takt Time, it is for this reason that the company maintains high levels of inventory of both finished product and in each of its processes to cushion the delivery of customer requirements, as well as their respective delivery times.

Grafico 3.4 Comparative TT – PCT



Source: Information obtained in the field

It can also be seen that there is an availability of 61.97% on the line, which means that the company maintains more than a third of its availability as unproductive time (38.03%) derived from the continuous unscheduled stoppages it keeps in each one of its areas observing that the causes of said stoppages are mainly due to the lack of maintenance in the equipment, the bad planning for the requirement of the raw material and in some cases to the bad programming of the production to supply each one of the respective areas.

Global Effectiveness of the Equipment (OEE)

The OEE is an indicator that in percentage terms highlights how the process is, because it encompasses availability, performance and quality in the machinery used in the production line (Villaseñor, 2008). It is important to mention that this indicator must be constantly monitored and at the same time each time interval that the company considers necessary must be updated, or each time improvements or changes are made in the production line, to make sure that it has really had an best result.

In this indicator, three factors are considered:

1. Equipment availability
2. performance
3. Quality

For the first, the total productive time is considered (subtracting from the total available time the unplanned downtime such as equipment failures, supply problems, poor quality, etc.) over the total available time multiplied by one hundred, (from the working day are subtracted the planned downtimes such as start, meal, cleaning etc.).

To calculate the yield (table 3.6), the actual production of the production station or line (obtained from the productive capacity by subtracting the micro-stops, or the reduced speed) from the production capacity multiplied by one hundred is determined.

For the quality, the good production (obtained, subtracting from the real production the pieces that do not fulfill the specifications of the client either of the station or production line) on the real production multiplied by one hundred. Once the data of each one of the work stations has been obtained, the OEE of the production line is obtained (Hernández & Vizán, 2013).

Table 3.6 Calculation of the OEE of the production line.

Availability	Seg.	Factor
Total productive time	2,675,400.00	87.67%
Programmed dead time	175,800.00	
Total available time	2,851,200.00	
performance	**Kg.**	**Factor**
Real production	25,896.23	34.95%
Micropairs, reduced speed	12,484.16	
Productive capacity	38,380.39	
Quality	**Kg.**	**Factor**
Good production	25,587.85	97.62%
Rework, defective	308.39	
Real production	25,896.23	
OEE = Availability * Performance * Quality		**OEE**
		29.91%

Source: Information obtained in the field

An OEE of less than 65% in world-class companies is considered unacceptable, or of very low competitiveness; in the case of the company, there is an OEE of 29.91%, which is well below the acceptance rates, with the performance with the least competitive value, for which the company must significantly reduce all unscheduled stoppages that remain low productivity to your processes.

Fase 5 Project proposal

From the results obtained in the technical study through the VSM tools the Tack Time - PCT analysis and the calculation of the OEE we realize that the company maintains multiple problems of which the most significant are:

a. Lack of application of the maintenance program to the equipment,
b. The frequent stoppages are not programs that each of the teams present during the work days, whether due to maintenance, quality, lack of material, or processing problems.
c. The low production that is manufactured by the constant unscheduled stoppages.
d. The low quality of the raw material and the constant monitoring in the different stages of the process to guarantee the quality of the yarn
e. The lack of reliable controls that allow identifying variations in the process in order to avoid transfers of problems to subsequent processes.
f. The accumulation of materials in each of the operations generating the use of space and risks of abuse or damage to the material.
g. The lack of technology for efficient quality control.

From the previous points a portfolio of projects is proposed, exhibited in the VSM figure 5, with technical feasibility to be susceptible to be developed and implemented for the correction and / or improvement of its operations, these options allow us to eliminate one or several problems that currently they appear in their productive area.

1. Design and development of a prototype for fiber and yarn winding quality tests.
2. Development of operational availability system for the administration of downtime and line stops.
3. Design and development of carda machine to guarantee the uniformity of the fiber.
4. Development of production program system.
5. Development of artificial vision system for the detection of yarn fiber uniformity in carding process.
6. Modification of yarn guide and spindle in continuous machine for the reduction of yarn breaks.
7. Implementation of kanban for the improvement of the flow of production and decrease of inventories.
8. Redistribution of the plant engineering of the production area for the reduction of inventories and material transfers.
9. Reformulation of dyeing recipes for reducing rework.
10. Development of maintenance system and andón board for quick response to failures presented during the day.

For the selection of the technological projects to be developed and implemented in the production line, it is left to the decision of the general management and the accounting department taking into account the impact on their operations, their need and their availability to carry out investments, so which was chosen in a first line of action to improve the quality of the yarn process, even when the production that the company took and according to the OEE the quality is relatively good; To achieve this, a lot of resources were wasted, such as time in rework and line stops, and taking the experience of the production experts, it was determined that the key process to reduce unscheduled stoppages and rework is in the fiber preparation where the machines designed to make the alignment of all fiber to ensure the uniformity of these, however the machines available for this process do not have an instrument or continuous monitoring system to monitor this process, leaving this work in the decision criteria of the operator, for which the development of an artificial vision system is proposed for the detection of the uniformity of the yarn fiber in the carding process.

For the second proposal, a project was considered that would allow the elimination of other waste, such as the accumulation of materials between processes, the reduction of unscheduled stoppages, the manipulation of materials, the improvement of information channels between the different productive and administrative areas, as well as the with key indicators to facilitate decision making and speed up response times, which is why we decided to implement a kanban system with artificial vision for the acquisition of information in order to increase the added value of the resources used in the production line.

Both proposals are decided to participate to obtain funds from the program of stimuli to the research, technological development and innovation of CONACYT in the modality of INNOVAPYME being these accepted for its implementation and development for the benefit of the company.

Project 1 (Application No. 000000000199635)

Technological development of fiber filament coating by continuous torsion to ensure uniformity by Bayesian prediction.

The technological development will allow:

1. Manufacture of yarn with central core that allows to support the different fiber compositions.
2. Monitoring by artificial vision of fiber, to ensure the amount of fiber during the manufacturing process

The objective of this project is a technological development to ensure uniformity by Bayesian prediction in the manufacture of yarn, it is intended to avoid 30% of waste in manufacturing due to the lack of homogeneity of the fiber in the process given the nature of the fiber , the solution is to develop a system that allows to predict the moment where the yarn will come out with fiber variations outside the standard, there the process will stop before it becomes entangled in the cones, unlike the competitors they waste complete cones when they are detected After the manufacturing process, the evidence that this type of improvement is correct are the new machines that have been patented in Asian countries, where innovations are aimed at guaranteeing the diameter, finish, length, and shape of the yarn, as well as the composition of fiber and the effect. In such a way that these values are very close to the real values. This type of process has been the trend of the thread in the coming years globally

Scientific-technological objectives

1. Design of high-speed artificial vision system for wire monitoring with Bayesian prediction algorithms.
2. Monitor the process by Bayesian prediction.

Expected benefits

1. Obtain the automated and accurate monitoring system for the manufacture of yarn
2. Obtain a monitoring system for the critical variables of the process (diameter, shape, composition and effect).
3. Increase productivity by reducing waste by not complying with compositional characteristics.
4. Offer a better customer service that meets the quality standards NMX-A-049-1983, and MX-A-147-1970.
5. Satisfying the national market and increasing the participation in the textile industry by 7%.
6. Obtain a spinning prototype with artificial vision monitoring.
7. Involve students in the project for the realization of stays and stays.
8. Strengthen the Business-HEIs link.
9. Position the participating HEIs as an option for companies in the region that wish to carry out technological developments.
10. Increase the competitiveness of textile companies
11. Maintain and / or increase the number of jobs in the textile industry

Impacts

1. Technological development of a system for monitoring process variables and yarn winding, to increase productivity by predicting failures ensuring yarn quality and losses by winding yarns of different dimensions to those specified.
2. Generation of employment sources for the textile company of the Tlaxcala-Puebla region.
3. Increase the permanence in the market of the company when venturing into new market segments with few national competitors.
4. Participation in external markets, creating technology-based products and processes that meet international and export quality standards.

Results obtained

At the end of the project, the results obtained from the implementation of the technological development were:

1. Reduction of operating costs given that waste levels were reduced.
2. Increase in sales resulting from the reduction of waste in the company, not only decreased this index, but this production became an increase in volume to offer more production to its customers.
3. Higher profits due to the decrease of its product waste and the increase in its sales.
4. Three new products were developed since, having a greater control of their processes, their quality was benefited and the opportunity is generated to design and produce a new line of products that previously was difficult to manufacture, due to the conditions that prevailed in the company.
5. A patent is generated to protect the technological development implemented, as well as the type of processing that the company will use to manufacture the new product line.

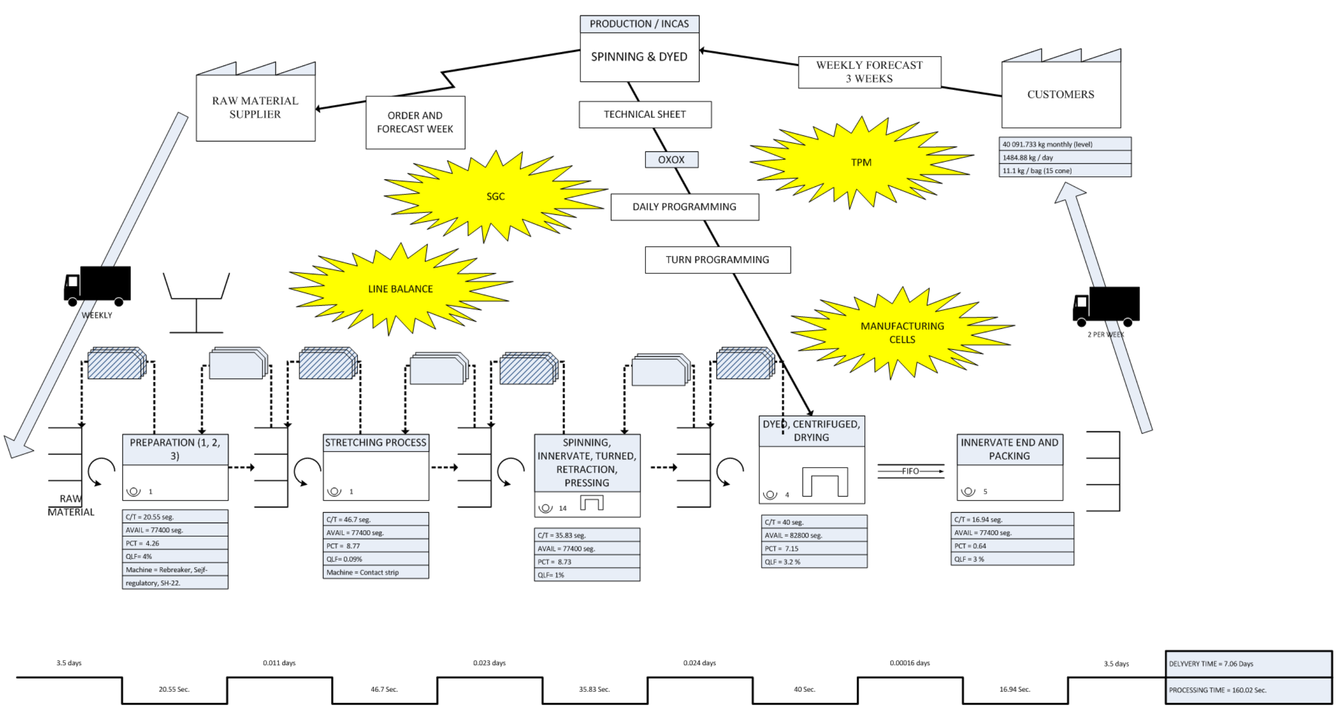
Project 2 (Application No. 000000000218755)

Kanban system with artificial vision for information acquisition in order to increase the Lean Time (added value) of the resources used in the production line under the One Piece Flow concept.

His current goal is the technological development of an automation system with a human touch called Kanban, (Socconini, 2016). Which, through the use of artificial vision cameras and a new flow of materials, will allow to control the production volume through the use of QR labels placed in the containers and sensors in conveyor belts, which will be processed and fed back by the system to project real-time results both in screens located in each thread process and in administrative areas, allowing the production plan to communicate only to the final assembly line, this line will go to the subsequent processes to extract production lots firing a chain of communication between these processes, where each will know automatically how and when to produce the parts required by the end customer avoiding the generation of isolated processes and therefore overproduction, in this way the management will be done backwards the process of complete manufacturing, resulting in the action of the required conditions significantly reducing the management work.

This technological development will allow to reduce the waste of overprocessing, scrap, response times, delivery times, inventory reduction, quality increase, and a better management of production planning (figure 3.6).

Figure 3.6 Value chain future state map

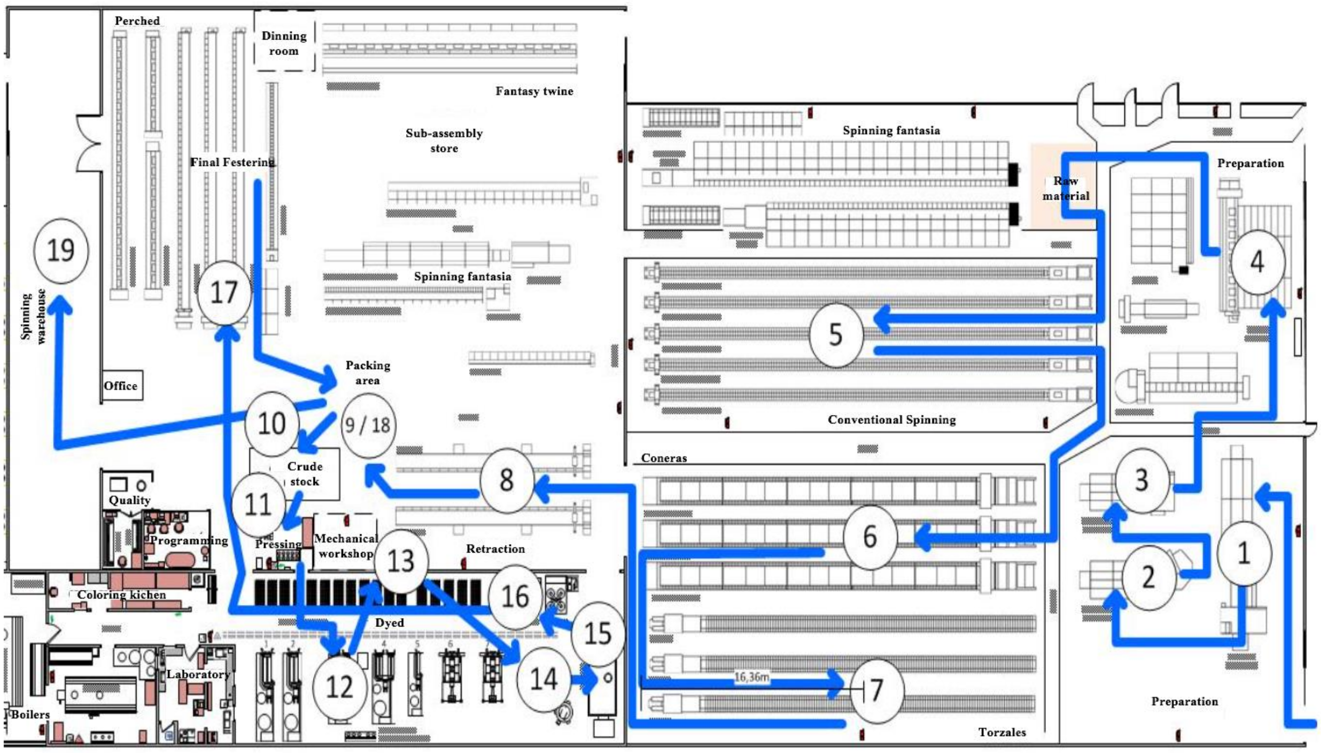


Source: Information obtained in the field

Distribution of physical spaces

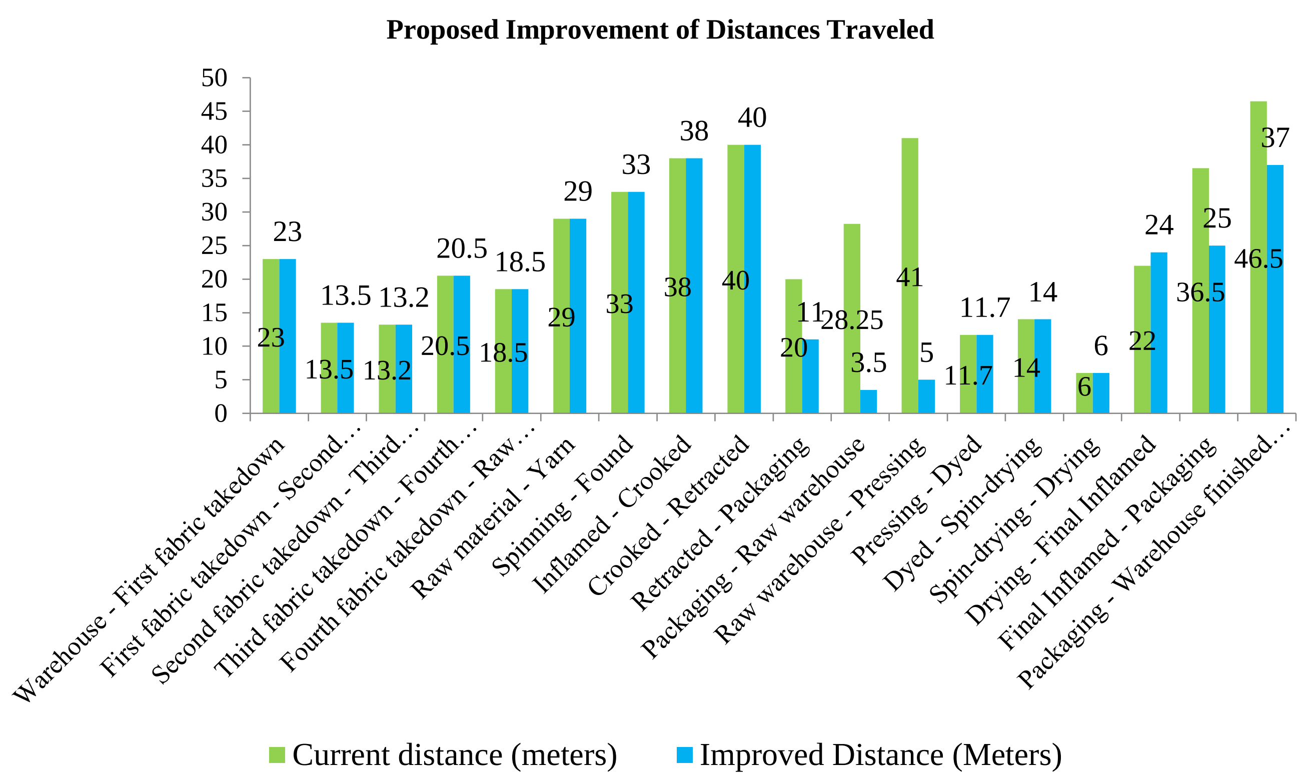
According to the route diagram of the production line (figure 3.3) deficiencies have been found that lead to the material being moved from one end to the other inside the plant, causing an increase in waste such as transportation and unnecessary movements; therefore, a redistribution of spaces is proposed to decrease the distances of transfer and therefore ensure a better flow of material. Next, the route diagram (figure 3.7) is presented, which is intended to decrease approximately 20% in distances or reduce the trajectory around 88.75 meters.

Figure 3.7 Layout with proposal of the manufacturing process



Source: Information obtained field

Grafico 3.5 Distances traveled from the process by improved area



Source: Information obtained from the survey

In graphic 3.5 the distance traveled in a before and after is observed, in blue the improvements are observed, and in green color the current distance is observed; where the decrease of distances in some areas is observed although they were not in all given that some equipment by its condition and feeding of inputs and resources is difficult to move them if it is possible to improve the distribution of some others to simplify the movements and movements of materials.

Scientific-technological objectives

1. System design by Kanban with artificial vision for process monitoring with Bayesian prediction
2. Synchronization of the process to increase the flow of production to subsequent processes
3. Monitoring the process by Bayesian prediction in real time.

Expected benefits

The Kanban system with artificial vision will be obtained for information acquisition in the thread production line which will transmit information in real time of the pacemaker process to each one of the subsequent processes through database interface visualized in screens placed in each department of work which will show the status of the preceding process in order to manufacture only the necessary parts with the necessary materials, at the time they are needed and in the quantity in which the customer is needed. With this system is expected to improve the synchronization between processes as well as improving the flow of both information and materials, while it is expected to decrease the scrap index by 30% of the current value, reduce delivery times from 32 days to 7.6 days with respect to inventory levels, this will reduce delivery times and therefore customer claims for lack of product.

Impacts

A Kanban system with artificial vision and processing of material status in the productive areas, will allow the company to move from a traditional process to a world-class manufacturing process with the use of new lean systems that will rebound, in various competitive advantages:

1. The system will allow to synchronize the yarn processes avoiding the generation of productive islands disconnected with the voice of the client, allowing him to market products with world-class processes of excellence.
2. The number of batches recovered in the dyeing area will be reduced by 10% with respect to the current value.
3. By implementing the Kanban system, a more efficient administration of resources will be obtained, especially human resources, by assigning activities that generate added value to the product.
4. When realizing the prototype of the Kanban system with artificial vision with technology of the HEIs it will be less expensive the redesigns, repair and damage updates to have local specialists.
5. The technology and the services of lean manufacturing by artificial vision can be transferred to any company in Mexico, companies of the central zone of Mexico and regional where it can be transferred without major modifications and be used for other applications and / or processes.
6. Upon entering the world-class manufacturing in Mexico, it will allow it to be the only manufacturer in Latin America with world-class processes supported by artificial vision technology and Bayesian prediction.
7. Offer a better service to the client that satisfies the quality standards (NMX-A-049-1983, and NMX-A-147-1970)
8. Satisfying the national market and increasing the industry's participation in this sector by 7%.

5. Results

Within the results obtained:

1. Although there was no implementation of the Lean Manufacturing methodology, the use of the value chain and its auxiliary tools was a trigger to identify areas of opportunity and guide the process of continuous improvement.
2. Regarding the technical feasibility and viability of the portfolio of technological innovation projects, a portfolio of 10 feasible projects is generated.

3. For the analysis of the viability of the portfolio of technological innovation projects, the technological projects to be developed and implemented in the production line are left to the decision of the general management and the accounting department, taking into account the impact on their operations, their need and your availability to carry out investments.
4. Participates with technological innovation projects in the program of incentives to technological innovation of CONACyT.
   a. Project number 5 of the project portfolio is presented in the convocation of the incentive program for research, technological development and innovation 2013 of CONACYT, in its INNOVAPYME modality supported with $ 2, 380,000. (CONACYT, 2013)
   b. The project number 7 of the project portfolio is presented in convocation of the program of stimuli to the investigation, technological development and innovation 2014 of CONACYT, in its modality of INNOVAPYME supported with $ 4, 410,000. (CONACYT, 2014)
5. Training of human resources, qualification of a student of the academic program of industrial engineering of the Polytechnic University of Tlaxcala.
6. Academic production for the academic body with registration PRODEP CA-04-UPTLAX

6. Conclusions

A company can grow as much as it has potential to face the problems that arise; In this analysis we have studied how is currently the production line of its main products (parent line), where deficiencies were found but also capabilities, which if you work on them, it is evident that there will be crucial changes that will allow development and be a leading company in the field, which will be possible only with hard work, because the benefits are not immediately tangible, it requires dedication, human potential and time, including years to see positive results.

The methodology used is considered a good practice since it supported the technical study under the CONACyT norm of the two proposed projects. The portfolios of projects under this methodology represent a business opportunity to reduce manufacturing costs to integrate world-class processes, and be benefited with economic support for the development of their projects that aim to increase the integration of national inputs and give a step to consolidate the productive chains.

Through the VSM tool, it is possible to analyze in graphic form how the value chain is, and considering the business strategy of the company; be in the possibility of establishing technological and innovation strategies that contribute to improving the competitiveness of the company.

The purpose of these proposals was on the one hand to increase the productivity of the company through the reduction of waste generated in their operational areas, improving the information flow and quality of these areas and on the other hand creating future lines of action such as deepening the value of existing processes, streamlining its administration process, reducing its deficit of specialized knowledge and promoting a global and competitive vision to face the challenges and opportunities for the company to access new markets, expand its technological base and of knowledge, and increase its production.

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