OPTIMISATION OF A PILLOW PRODUCTION LINE APPLYING LEAN PRINCIPLES

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ABSTRACT

Manufacturing companies throughout the world are interested in reducing the time between a customer placing an order and them receiving the payment for that order. This premise is something that is a central characteristic for the Lean philosophy, and is one of the reasons to apply it. Today manufacturers around the world are embracing Lean techniques in order to reduce waste and increase productivity, and also increase the inventory turns, which reflects in an improvement of cash flow for the company. Nowadays, with all the financial turmoil, every company is looking forward to reduce the inventories, to work with Just in Time supply chains, to develop production systems that reduce the scrap and produce only what is needed, saving space, and freeing up time to work on new design and be at the edge of innovation in order to gain market share and keep improving.

This master thesis is focused on implementing the Lean principles in a pillow production line, in order to achieve it, a series of techniques to assess the facility where implemented, which allowed to understand how the facility was working, where is the bottleneck, and to understand the function of it as a system, avoiding to focus on a single point but viewing it as a whole, where each part contributes in a specific and unique way, but where all of them are necessary.

Applying Lean principles is a daunting task that takes a long time, a never ending trial and error process, because of this the goal of this study is to develop the bases for a Lean transformation, a schedule for the implementation will be developed and proposed to the company, after analyzing the facility. The study reveals that it is possible to reduce the lead-time of the facility in 60%, and avoid the backorders situation that is present in the company, improving also the service level.

Keywords: lead-time, Value Stream Map, supermarket pull system, FIFO lane, waste, throughput time, delivery, bottleneck, schedule, inventory, Lean philosophy.
PREFACE

This master thesis presents a theoretical analysis of Lean philosophy and its application to a production facility, with a simulation analysis to understand better its implication in the functioning of the company.

The theoretical framework establishes the background necessary to understand the analysis of the data, and also allows understanding the decisions that were made in the schedule for a Lean implementation that is proposed. Almohadas Cabanna allowed me to show some data about their dispatch process and the timings as a whole, but some specific data about the processes was protected.

I would like to thanks Professor Jerzy Mikler for his support and advice, his dedication and help, and for keeping all the communication channels open, especially because this study was conducted from Caracas, Venezuela. Also I like to thank Professor Ove Boyard for his support throughout the masters program, and his help to have the possibility to conduct a study on lean implementation with a practical applicability.

Finally I would like to have a special mention of the employees in the facility, without which this project would never have a success end, and because of their collaboration and great attitude towards this study.
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1. INTRODUCTION

This master thesis is focused on the study, feasibility analysis, and implementation design of a Lean system for a pillow manufacturing facility that is located in Caracas, Venezuela. In particular the study attempts to understand the present state of the company, its position in the industry, and how a Lean system can be placed in order to improve it. The project was based on the reduction of the Lead time that the company offered, looking for a service improvement, and also to educate the personnel to work towards a pull system and to achieve the Takt time required to meet the market demand.

The reduction of the lead time will also generate an increment of the flexibility of the facility, and thus an improve response to sudden demands or late order placement, which is a common issue for the medical industry. Also this work faced the problem of communication blockage from the costumer side of the equation, in this matter education was tried, in order to make understand the sales department that this late orders where a huge problem for the facility, and that this generated a bullwhip effect that was counterproductive.

This work will describe first the theoretical framework from where it is sustained, in order to understand why the path that was taken was selected, then a present state of the manufacturing facility at the starting moment of this study is presented and analyzed, and based on the theory and the assessment made during the analysis some initial modifications were made, and directly implemented with clear impacts in the production process and the lead time of the company.

After this initial assessment and modifications were made, a second present state was studied, this was performed in the third week of March, once the first changes were already in place and working smoothly, and again it was analyzed based on the theory; and a plan for the Lean implementation is prepared with a tentative timeframe for its achievement, with recommendations for future improvements or areas of interest were it is possible to keep evolving.

1.1. Background
Almohadas Cabanna C.A. is a Venezuelan manufacturing company, which is dedicated to the upholstery industry since 2005, but it is being working in the Venezuelan market since 1992. It is located in Caracas, the capital city of Venezuela, from where all the operations are held, from manufacturing and administrative, to delivery and storage.

The company is specifically dedicated to the pillow industry, working basically with wholesalers as their primary clients, but they also work with small business shops and the medical industry, that make orders directly to them. The company has its own fleet of trucks that make the delivery to the whole country from the storage capacity located in Caracas.

Venezuela has a population of 28MM inhabitants, which leads to a market of pillows of the same size, because basically everyone uses them, and is a potential customer. But based on the monthly figures for the industry, it is a 500000 industry. Also it is very important to see some financial figures from Venezuela, the inflation of the economy it’s been in double digits for more than 10 years in a row, also the GDP index is in negative numbers for the second year in a row, making the economy to fall behind, the unemployment rate is around 10%, but it includes the non-formal activity, like street sellers, and people that is underemployed as employed population. This makes the country economical situation absolutely instable and very difficult to assess and predict. Besides the money exchange system is blocked since 2002 (www.cadivi.gob.ve, this is the official web site of the government for the assignation of the foreign money), and adding a huge amount of bureaucracy, making many laborious procedures, and in many cases not assigning the money, generating a parallel market for the dollars that is twice the price of the official one, making the imports of some good, like raw materials, very difficult and expensive.

Also in Venezuela the political situation is in constant turmoil, having protests and strikes constantly, based on a very polarized society, due to poor government decisions and an opposition that is divided, and generating, in many cases, problems for the country to function normally in the manufacturing world. Also due to a public policy that is going towards statization of the economy, scaring the private investment, and making it very difficult for the industry to evolve and grow.
Also due to the political characteristics of the country, it is very difficult to adjust the prices of the products, because of government pressures to the wholesalers and stores to not increase the prices or they might face an expropriation, this has already been occurring in the country, which leads to have a war style of economy, where many raw materials are difficult to find, and when they are offered the price is very high and you cannot absorb the difference in the product, so the negotiations with the clients are very intense and difficult.

1.2. Problem Statement

The company has been experience some issues since February 2009, they have been constantly late in their deliveries, due to a lack of flexibility in the production line, and a miss management of the storage area and some communication problems between the sales department and the production department. The company needs to understand better its demand in order to determine the takt time needed to meet its compromises, and from there start the whole analysis process of the facility, also the lead time needs to be studied, and if possible reduced in order to increase the service that is offered to the customers, as we all know time is money, so if we reduce the lead time, this will increase the Return On Investment (ROI), and also due to the characteristics of the product if it is not at the store it is not there at all.

This project will work closely with the production facility in order to achieve a consensual plan to meet the takt time, to improve the communication process between the sales department and the production department, and also to introduce the employees to the advantages of working with a Make To Order (MTO) system mixed with the existing Make To Stock (MTS).

1.3. Objectives

I. Reduce the lead time of the facility in order to meet the demand requirements
   i. Understand the demand needs and calculate the takt time required
ii. Analyze the present state of the company
iii. Determine and generate a future state of the company
iv. Create a plan for the implementation of the future state of the facility

1.4. Methodology

The methodology that utilized in this master thesis was a combination of the three research approaches that exist, the analytical approach, the systems approach and the actors approach. This study intends at first to understand how the whole facility works, and this is the actors approach, because at the end who drives the company is the employees that are involved in every activity, and their performance and behavior affects what is happening(1).

Then an analysis of the whole system itself is performed, being this the system approach, where the interaction of the different components of the facility is taken into consideration, looking at their relations and how each of them affects the other; by using the Value Stream Mapping tool and extending these to the utilization of Extend, this study strives to understand how the facility behaves in the present state, and how the different changes proposed will affect it(1).

And finally once the system approach was used, and some specific areas where identified an analytical approach was utilized, separating the facility into its entities and understanding, analyzing and modifying only the ones that are of interest or that have the biggest impact in this research process(1).

The methodology that was put in place was selected due to its flexibility in terms of analyzing each level of the facility, it allowed to understand the whole system, and as the Lean philosophy explains, it is more important to improve the whole as a system than to implement an improvement to a small section of the facility and by that generate an island of excellence, that will perform much better than the rest, but at the end might disturb the system (2), and the final result, that is reduce the lead time for the customer will not be improved. It is important to bear in mind that it is more important to focus on the facility as a whole, which
needs to work in a coordinated way, than just trying to improve some parts of it that at the end instead of improving the facility are only generating noise to it.

1.5. Delimitations

This master thesis will focus on the different processes that take place on the pillow production facility; also will take into account the raw material supply process in terms of the lead time that is offered from the suppliers and how this affects the implementation of a Lean philosophy. The study will verify the processes for different variation of the products, in order to understand how the processing time of each of them affects the overall lead time of the facility.

Even though this report will talk about the advantages of sharing information between producers, the plant itself, and the customer, could be the wholesaler or any other, no attempt to achieve this was made during this study, due to lack of time, and some issues regarding the management system.

All the results obtained here regarding the facility where taken in situ, but the previous metrics are not confirmable, in term of validity so they lack credibility, even though they were taken into account to show some improvements in the facility, and also to explain to high level of management the advantages of the changes that are proposed.
2. THEORETICAL FRAMEWORK

2.1. The product. Pillow

The product that is made by the facility is a pillow. This product is composed by different parts that are put into place, there are two raw materials that are used and processed, and then they go through an assembly process that has 4 different procedures, this will be explained in detail later on this report.

The raw materials that used are fabric and 100% polyester staple fiber semi dull raw white; both come in rolls and needs to go through some process before it comes into the assembly line. The processes for the fabric are:

i. Extend the rolls of fabric
ii. Mark them with the size that will be produced
iii. Cut the fabric into the dimension
iv. Sew the fabric

The polyester stable fiber goes through one specific process, the carding process, this only opens the raw material, in order to give some softness and recovery when is pressed, and then goes to a feeding process into the covers that where made separately, as explained before.

After the raw materials go through their pre-processing, they are taken into the assembly line, the fiber that was carded is feed into the cover, then is weighted to assure that it has the right amount of fiber inside, after that the cover is closed by a sewing process, then the closed cover is punched to give it the correct form, then is putted into a plastic bag and sealed, and finally is putted into a plastic bag to conform the bulk of the product (the size of the bulk varies from product to product), and then is moved to the storage facility where it waits to be delivered. The whole process will be explained in a greater detail when this report goes into the analytical section.

2.2. The Lean philosophy
2.2.1. What is Lean?

Lean is a philosophy of work, a way of doing thing that seeks towards the reduction of the time between the placement of an order and the money being received by the producer, or the store or the entity that was being asked for the product/service (2).

“All we are trying to do is to reduce the time from order to cash”.

Taichi Ohno

Lean is more about what is performed everyday without being told. Lean is not about cost reduction, is about improvement as a system, and is about being better for the customer. Lean seeks the “ideal way”, always look for the best way of doing the activity. Have a vision, and then look on how to achieve it (2).

Lean is not tool or even an integrated set of tools. Lean is a mindset, a way of thinking, is a view of thing that differs from the traditional mass production (3).

Lean is “system”; Lean is not about manufacturing or service but about the system that brings both of these together. Believing that optimizing the individual parts will lead to optimizing the whole represents possible the greatest barrier to Lean. System approach means the focus should be on the organization or entity as a whole before attention is paid to the parts. Consider the Lean Value Stream, from raw materials to the end customer, to avoid islands of excellence (2).

Lean is also continuous learning, the real source of power lies in its ability to learn from mistakes, and to continuously improve. Mistakes are seen as opportunities to improve, the two pillars of lean are (2):

i. Kaizen: continuous improvement

ii. Hansei: honest self-reflection

Lean is both revolution and evolution; revolution because it goes in another direction from mass production and economy of scale. Evolution because you need to see your own system and improve it. Lean also is “distributed decision”, excess of information needs to be suppressed. Perhaps the greatest opportunity for Lean is not on the office or factory floors, but in simplification and decentralization that enables the whole swathes of overhead and
administration to be eliminated. Lean can be seen as green, because focusing on waste of materials and energy it can also be profitable and attractive to the customers (2).

In the Lean toolbox the authors propose the following formula for Lean:

\[
\text{Load} = \text{Value demand} + \text{Failure demand} - \text{Capacity} = \text{Work} + \text{Waste (NVA)}
\]

![Figure 1. Lean Formula](image)

Load – the amount of work imposed  
Capacity – resources available to do the work

### 2.2.2. Lean principles

The Lean philosophy has some principles, which were derived from the original lean implementation (Toyota and Taichi Ohno, the father of this way of viewing the customers, and the relation between the processes and what is actually important), from the Lean Toolbox a set of principles are mentioned by the authors:

i. The starting point is to specify value from the point of view of the customer. This is an established marketing idea (that customers buy results, not products – a clean shirt, not a washing machine). Too often, however, manufacturers give the customers what is convenient for the manufacturer. Or deemed economic for the customer.

ii. Then identify the Value Stream. This is the sequence of processes all the way from raw material to final customer, or from product concept to final launch. If possible look at the whole supply chain. You are only as good as your weakest
link, supply chains compete, not companies. Focus on the object, not the department, machine or process step. Think economies of time rather than economies of scale. Map and measure performance of the value stream end-to-end, not departmentally.

iii. The third principle is flow. Make value flow. If possible use one-piece or one-document flow. Keep it moving. Avoid batch and queue, or at least continuously reduce them and the obstacles in their way. Never delay a value adding step by a non-value adding one. Flow requires much preparation activity. But the important thing is vision: have in mind a guiding strategy that will move you inexorably towards simple, slim and swift customer flow.

iv. Then comes Pull. Having set up the framework for flow, only operate as needed. Pull means short-term response to the customer’s rate of demand, and not over producing. Think about pull on two levels: on the macro level most organizations will have to push up to certain point and respond to final customer pull signal thereafter. On the micro level, respond to pull signals as, for instance, when additional staffs are needed at supermarket checkout to avoid excessive queues. Attention to both levels is necessary.

v. Finally comes perfection. Having worked through the previous principles, suddenly now “perfection” seems more possible. Perfection does not only means defect free – it means delivering exactly what the customer wants, exactly when it wants, at a fair price and with minimum waste. Be aware of benchmarking – the real benchmark is zero waste.

### 2.2.3. Characteristics of Lean

The following characteristics where obtained from The Lean Toolbox, and is a recompilation of 25 characteristics that the authors considered to be at the core of the Lean thinking, and during this master thesis they were constantly utilized:
i. **Customer**: the external customer is both the starting and ending point. Seek to maximize value to the customer. Optimize around the customer, not around internal operations. Understand the customer’s true demand, in price, delivery and quality – not what can be supplied.

ii. **Purpose**: the way to reduce waste, complexity, and bureaucracy.

iii. **Simplicity**: Lean is not simple, but simplicity pervades. Simplicity in operation, system, technology, control, and the goal.

   “Simplicity is the ultimate sophistication”

   Leonardo Da Vinci

iv. **Waste**: waste is endemic. Learn to recognize it, and seek to reduce it, always.

v. **Process**: organize and think by end-to-end process. Think horizontal, not vertical. Concentrate on the way the product moves, not on the way the machines, people or customer moves. Map to understand the process.

vi. **Visibility**: seek to make all operations as visible and transparent as possible. Control this by sight. Adopt the visual factory.

vii. **Regularity**: regularity makes for “no surprises” operations. We run our lives on regularity; we should run our plants on this basis too.

viii. **Flow**: seek “keep it moving at the customer rate”, “one piece flow” manufacture. Synchronize operations so that the streams meet just in time. Flow should be the aim at cell level, in-company and along supply chains.

ix. **Evenness**: “heijunka” or leveling is the “secret weapon” for flow and quality. Seek ways to level the schedule, to level sell, to level buy.

x. **Pull**: seek for operations to work at the customer’s rate of demand. Avoid overproduction. Have pull based demand chains, not push based supply chains. Pull should take at the customer’s demand rate.

xi. **Postponement**: delay activities and commit to product variety as late as possible so you retain flexibility and reduce waste and risk.

xii. **Prevention**: seek to prevent problems and waste, rather than to inspect and fix. Shift the emphasis from failure and appraisal to prevention.
xiii. Time: seek to reduce overall time to make, deliver, and introduce new products. Use simultaneous, parallel, and overlapping processes in operations, design, and support services. Time is the best single overall measure.

xiv. Improvement: Improvement, continuous improvement in particular, is everyone’s concern.

xv. Partnership: seek co-operative working both internally between functions, and externally with suppliers. Seek to use teams, not individuals, internally and externally. Employees are partners too. Seek to build trust.

xvi. Value networks: the greatest opportunities for cost, quality, delivery and flexibility lie with cooperative networks. Supply chains compete, not companies. But each member of the chain also needs to add value.

xvii. Gemba: go to where the action is happening and seek the facts. Manage by walking around. Implementation takes place on the floor, not in the office. Encourage the gemba spirit throughout.

xviii. Questioning (and listening): encourage a questioning culture. Ask why several times to try get to the root cause.

xix. Variation reduction: variation in time and quantity is found in every process from supply chain demand amplification to dimensional variation. It is a great enemy of Lean.

xx. Avoiding overburden: overloading means less than full loading, and applies to people and machines – otherwise with just a little disturbance or variation you will miss the schedule. And bottlenecks need special attention.

xxi. Participation: give operators the first opportunity to solve problems. All employees should share responsibility for success and failure. True participation implies full information sharing.

xxii. Thinking small: specify the smallest capable machine, and then build capacity in increments. Get best value out of existing machines before acquiring new ones. Break the “economy of scale” concept by flexible labour and machines.
xxiii. Trust: if we truly believe in participation and cutting waste, we have to build trust. Trust allows great swaths of bureaucracy and time to be removed internally and externally.

xxiv. Knowledge: knowledge workers are the engine of today’s corporations. Knowledge is build through the scientific method, through PDCA.

xxv. Humility: the more you strive for Lean, the more you realize how little you know, and how much there is yet to learn. Learning begins with humility.

2.2.4. The Toyota Way

A brief reference to the Toyota Way was included in the master thesis theoretical framework because of its relevance and importance when we decided to apply Lean thinking and techniques, it combines the theory related to a very successful and known case of study, and shows a path to follow, which was very helpful when this study was conducted and contributed a great deal to the suggestions and the plan that was drown to the Lean transformation.

“The key to the Toyota way and what makes Toyota stand out is not any of the individual elements… But what is important is having all the elements together as a system. It must be practisioned every day in a very consistent manner not in spurts”

Fujio Cho

The executive summary of the Toyota way is presented next; this was obtained from the book itself, and based on what the authors mention it is very similar to what is distributed throughout the company in order to inculcate and communicate the philosophy of the company (3):

- **Section I: long-term philosophy**
  - i. **Principle 1:** base your management decisions on a long-term philosophy, even at the expense of short-term financial goals.
    - Have a philosophical sense of purpose that supersedes any short-term decision making.
Generate value for the customer, society, and the economy, it is your starting point.

Be responsible. Strive to decide your own fate. Believe in your own abilities

Section II: the right process will produce the right results

i. Principle 2: create continuous process flow to bring problems to the surface
   - Redesign work processes to achieve high-value-added, continuous flow. Try to reduce to zero the time that a project is waiting.
   - Create flow to move material and information fast as well as to link processes and people together.
   - Make flow evident throughout your organizational culture.

iii. Principle 3: use pull systems to avoid overproduction
   - Provide your down line customer in the production process with what they want, when they want it, and in the amount they want. Just in Time.
   - Minimize you WIP and warehousing of inventory.
   - Be responsible to the day-by-day shifts in customer demand. Try to avoid forecasting.

iv. Principle 4: level out the workload (Heijunka), work like the tortoise, not the hare
   - Eliminate waste is only one third. Eliminating overburden to people and equipment and eliminating unevenness in the production schedule are as important.
   - Work to level out the workload of all manufacturing and service processes. Avoid big batches.

v. Principle 5: build a culture of stopping to fix problems, to get quality right the first time
   - Quality for the customer drives your value position
   - Use all the quality assurance methods available (modern)
   - Build into you equipments the capability of detecting problems and stopping itself. Visual systems that alerts about problems.
   - Build into your culture the philosophy of stopping or slowing down to get quality right the first time

vi. Principle 6: standardize tasks are the foundation for continuous improvement and employee empowerment
- Use stable, repeatable methods to maintain the predictability, regular timing, and regular output.
- Standardize today’s best practices in each process, and empower to explore new ideas to improve those standards.

vii. Principle 7: use visual controls so no problems are hidden
- Use simple visual indicators to help people determine if they are following the standards
- Avoid using a computer screen
- Design simple visual systems at the place where the work is done
- Reduce your reports to one piece of paper wherever is possible.

viii. Principle 8: use only reliable, thoroughly tested technology that serves your people and processes
- Use technology to support people, not to replace people.
- New technology is often unreliable and difficult to standardize
- Conduct actual tests before adopting a new technology
- Nevertheless, encourage your people to consider new technologies

➢ Section III: add value to the organization by developing your people and partners
ix. Principle 9: grow leaders who thoroughly understand the work, live the philosophy, and tech it to others
- Grow leaders from within the organization
- Do not view the leader’s job as simple accomplishing and having good people skills. Must be role models.
- Must understand the daily work in great detail

x. Principle 10: develop exceptional people and teams who follow your company’s philosophy
- Create a strong, stable culture in which the company values and believes are widely shared.
- Train exceptional people individuals and teams to work
- Use cross-functional teams to improve quality and productivity
• Make an ongoing effort to teach individuals how to work together as teams towards a common goal

xi. Principle 11: Respect your extended network of partners and suppliers by challenging them and helping them improve
  • Have respect for your partners and suppliers and treat them as an extension of your business
  • Challenge your outside business partners to grow and develop

➢ Section IV: continuously solving root problems drives organizational learning

xii. Principle 12: go and see for yourself to thoroughly understand the situation
  • Solve problems and improve processes by going to the source and personally observing and verifying
  • Think and speak based on personally verified data
  • Even high-level managers should go and see things for themselves

xiii. Principle 13: Make decisions slowly by consensus, thoroughly considering all options; implement decisions rapidly
  • Do not pick a single direction unless you have considered other ways. Hear other ideas.
  • Discuss problems and potential solutions with all the affected

xiv. Principle 14: become a learning organization through relentless reflection and continuous improvement
  • Challenge your processes always to improve them
  • Design processes that require almost no inventory
  • Stable personnel
  • Make reflection a cornerstone
  • Learn by standardizing the best practices

It is also very important to mention the different wastes that Taichi Ohno identified as a source of delay; it is a key element to always keep in mind that we are striving to reduce the lead time, so the following are the wastes that we are trying to reduce or if possible to eliminate (3):
i. Overproduction: producing for which there is no order, which generates such wastes as: overstaffing and storage and transportation costs because of excess of inventory

ii. Waiting (time on hand): workers merely serving to watch an automated machine or having to stand around waiting for the next processing step, tool, supply, part, etc., or just plain having no work because of stock outs, lots of processing delays, equipment downtime, and capacity bottlenecks.

iii. Unnecessary transport or conveyance: carrying Work in Process (WIP) long distances, creating inefficient transport or moving materials, parts or finished goods into or out of storage or between processes.

iv. Over-processing or incorrect processing: taking unneeded steps to process the parts. Inefficiently processing.

v. Excess inventory: excess raw material, WIP, or finish goods causing longer lead times, obsolesce, damaged goods, transportation and storage costs and delay. Extra inventory hides problems such as production imbalances, late deliveries from suppliers, defects, equipment downtime and long setup times.

vi. Unnecessary movements: any wasted motion employees have to perform, such as looking for, reaching for, stacking parts, tools, etc. Also walking is waste.

vii. Defects: damage parts or products, re-work, scrap, replacement production, and inspection means wasteful handling, time, and effort.

viii. Unused employee creativity: losing time, ideas, skills, improvements, and learning opportunities.

The eight’s waste was added by the author, it is not part of the original Ohno view, but it is a source of great waste, because as we understand the Lean philosophy depend deeply in the involvement and the importance of Kaizen, and if the human talent is wasted, it will affect greatly the continuous improvement way of thinking.

Throughout the Toyota Way, the author, Professor Liker, always is reinforcing two basic things; first that you need to see the whole process, not small parts, try always to avoid island of excellence, and understand that every part will influence, that it is a system with many players; and the second is that you need to nurture your workforce, to make them feel that
they are truly part of the company, that they have to work for it because they are really taken into account, that without them the company is nothing.

### 2.2.5. Value Stream Mapping

A value stream is all the actions (both value added and non-value added) currently required to bring a product through the main flows essential to every product (4):

- The production flow from raw material into the arms of the customer
- The design flow from concept to launch

During this master thesis the Value Stream was a key element, because taking a value stream perspective means working on the big picture, not just individual processes, and improving the whole, not just optimizing the parts (4). As Prof. Liker says in his book, The Toyota Way, try to avoid the creation of islands of excellence, it is better to understand the whole flow, and then when the big picture is identified and the bottlenecks and constrains are clearly identified is when we start to improve small parts of the system.

The Value Stream Mapping technique is a very powerful tool for the Lean philosophy implementation, it allows you to see, visualize and understand how you process goes. This technique starts with the customer and ends at the raw material (or starts with the product launch and ends at the product conception or idea), going through all the activities, taking into account all the processes flow and information flow that goes with the product.

Value-Stream Mapping is an essential tool because (4):

- It helps to visualize more than just the single-process, i.e. assembly, welding, etc., in production. You can see the flow.
- It helps you to see more than waste. Mapping help you see the sources of waste in your value stream.
- It provides a common language for talking about manufacturing processes.
- It makes decisions about the flow apparent, so you can discuss them. Otherwise, many details and decisions on your shop floor just happen by default.
v. It ties together lean concepts and techniques, which helps you avoid “cherry picking”

vi. It forms the basis of an implementation plan. By helping you design how the whole door-to-door flow should operate – a missing piece in so many lean efforts - value stream maps become a blueprint for lean implementation. Imagine trying to build a house without a blueprint!

vii. It shows the linkage between the information flow and the material flow. No other tool does this.

viii. It is much more useful than quantitative tools and layout diagrams that produce a tally of non-value-added steps, lead time, distance traveled, the amount of inventory, and so on. Value stream mapping is a qualitative tool by which you describe in detail how your facility should operate in order to create flow. Numbers are good for creating a sense of urgency or as before/after measures. Value stream mapping is good for describing what you are actually going to do to affect those numbers.
3. PRESENT SITUATION ALMOHADAS CABANNA C.A.

3.1. Company present situation

Almohadas Cabanna C.A. is a company located in Caracas, Venezuela; that is experiencing saturation in their production process, regarding the amount of product needed by their customer and the dispatch process, which is generating delays. This present state regards the situation of the company in the beginning of this study, in January, and is important to mention that in those moments the company was trying to fulfill orders from October and November and December, so that indicated clearly that the company was experiencing problems with a long lead time.

Also the company has a very poor metrics system, and it was very difficult to identify the present state of the company. The only metric that was possible to identify was the amount of products that were being dispatch every month in average (see appendix A).

The company was dispatching around 30000 units each month, but in order to achieve this it was need to use a Logistics external player, that was done under a higher price when it’s compared to the cost of the internal logistics. Also the company was constantly behind schedule in terms of the production, they where all the time running late and at the maximum capacity, this means that any problem will delay everything.

It is possible to state that the company was starting to lose terrain to its competitors, due to a deteriorated image in terms of honoring their compromises.

3.2. Market position

Almohadas Cabanna C.A. is in the top 3 of the Venezuelan Market, with around 10% share of the market. The company started to experience during the year 2009 a decrease of the market share due to its inefficiency in the delivery. This product needs to be exposed in order to be bought. The market needs to be supplied constantly, the customers do not want to wait for the product, they want to go into a store and buy it, not to order and wait, this is called a
functional product (5), and Marshall L. Fisher says that it is a key factor to understand this and then identify the right Supply Chain for that. What competes is not the companies are the Supply Chains (2), the company that understands this, and works hard to apply the right Supply Chain will have a huge advantage that could mean to be competitive or not.

The market many times requires the product urgently, from one day to the other and in some cases the same day, meaning this that the facility will need a high degree of variability and flexibility in order to change the product that is being made, and have the order ready, or have a huge storage of finish goods in place; but this second options will mean to go against of the Lean principles, so we believe that a mix solution is needed, a supermarket of finished goods with a safety stock, that does not represents a big quantity but is enough to be able to respond properly to the market needs.

The instability in the demand of the product, especially from a specific type of client, makes a differentiation in the way some products are treated. The product that is design for that type of client has to be stored and ready for a last minute order; this will affect some Lean considerations, but is a need for the customer.
4. JANUARY 15: CURRENT STATE, MEASURES AND RESULTS

4.1. Almohadas Cabanna production process

The process starts with the cutting of the fabric rolls, from where the different cover sizes are obtained. Then the covers need to be sewed, this is performed by an outsourcing company, the fabric is transported in batches of 4000 units, and then this outsourcing company informs when the covers are ready, this means that the cover are sewed; and then the company sends a truck to pick them up; but this covers are not ready to go into the production line, first they need to be unfold, the covers once unfolded are placed in plastic bags in batches of 500.

After the covers are ready, they are taken to the loading position, there the cover are feed with the fiber that was already processed. The processing part is done as a before activity and is a continuous process, it is the same for all the products that are made.

Then the cover filled are weighted to verify that they have the right weight for the specific size, the operator in charge of this operation takes out or fills the cover to have the right weight, then the pillow is thrown to a point where the sew worker grabs them and closes them.

Then the pillow is thrown to the punching position, here the operator punches the pillows, in order to give it the form and distribute correctly the fiber inside, then it is placed into its individual plastic bag and sealed, this sealed bag with the pillow is placed in the middle of the facility, where it cumulates; and finally the pillows are grouped in order to form the bulks, this bulks depend the size that is being made, they vary from 5 to 14 units per bulk.

The processes shared the employees, the personnel in charge of the cut comes from the production line, so when the cut is needed they had to leave a sector of the production line and this of course generated a accumulation of WIP, normally after the pillows were sealed in their individual plastic bags. Also when the trucks needed to be loaded with the products employees from the production line need to be taken, so this uncompleted the production line process, once again making the pillows to cumulate in the shop floor.
It is very important to mention that the process did not had this final bulk conformation right away, actually the pillows were thrown into the floor, once they were sealed in their individual bag, and waited there to be grouped into their bulk, many times the product stayed there until the next day, accumulating more than 2000 units in the floor, creating a big mess for the next day, blocking the passage, making it very difficult to go through the shop floor.

Also the facility was very disorganized, and dirty; it was possible to find bulks anywhere, and mixed, making it very hard to understand what was actually in the factory, what were finished goods ready to be shipped. There was very little organization regarding the machinery, or how to place the materials, the material handling was very bad.

The plant layout was, in January 15, as follows (in order to understand better the drawing go to appendix B):

![Plant Layout](image)

**Figure 2. Almohadas Cabanna Plant layout January 15 2010**

### 4.2. Data Collection

The first data collected was the cycle times for each process, with the variation of each size. In order to simplify the task and due to the fact that it is one family of product, that all of
them go through the same process, only varying in the processing times due to the different size, only one size will be shown, also due to privacy the numbers will not be shown.

### Table 1. Almohada Cabanna Queen Process times

<table>
<thead>
<tr>
<th>Process</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>Ave</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feeding</td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loading</td>
<td>65</td>
<td>76</td>
<td>93</td>
<td>84</td>
<td>75</td>
<td>63</td>
<td>71</td>
<td>89</td>
<td>78</td>
<td>71</td>
<td>75</td>
</tr>
<tr>
<td>Weighting</td>
<td>40</td>
<td>45</td>
<td>42</td>
<td>48</td>
<td>43</td>
<td>45</td>
<td>42</td>
<td>47</td>
<td>45</td>
<td>43</td>
<td>45</td>
</tr>
<tr>
<td>Sewing</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Punch</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Forming +</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Envelope</td>
<td>40</td>
<td>45</td>
<td>42</td>
<td>48</td>
<td>43</td>
<td>45</td>
<td>42</td>
<td>47</td>
<td>45</td>
<td>43</td>
<td>45</td>
</tr>
<tr>
<td>Sealing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Packing</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
</tbody>
</table>

In order to obtain this values, the gemba principle (3) was used, a walk through the production plant with a stop watch, taking the times of each process 10 times, in order to get a good average. It was important to explain first to the labour that it was not to penalize them, so the operators shouldn't be afraid, or rush, just do the normal work. This was performed for each size.

Once this was obtained, the next step was to generate the VSM (in order to see a better picture of the VSM go to appendix B Drawings) with the process times, and this allowed obtaining the throughput time, the time that takes for a raw material to become a final product and be delivered.
In the VSM we can notice how the throughput time is 34.04 days, and actually a product only needs 0.4 days to go through the whole process. Also it was applied the Read a Plant Fast (RPA) technique (5), from where the following results were obtained:
<table>
<thead>
<tr>
<th>#</th>
<th>Questions</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Are visitors welcomed and given information about plant layout, workforce, customers, and products?</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Are ratings for customer satisfaction and product quality displayed?</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>3</td>
<td>Is the facility safe, clean, orderly, and well lit? Is the air quality good, and are noise levels low?</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>4</td>
<td>Does a visual labeling system identify and locate inventory, tools, processes, and flow?</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>5</td>
<td>Does everything have its own place, and is everything stored in place?</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>6</td>
<td>Are up-to-date operational goals and performance measures for those goals prominently posted?</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>7</td>
<td>Are production materials brought to and stored at line side rather than in separate inventory storage areas?</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Are work instructions and product quality specifications visible at all work areas?</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>9</td>
<td>Are updated charts on productivity, quality, safety, and problem solving visible for all teams?</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>10</td>
<td>Can the current state of the operation be viewed from a central control room, on a status board, or on a computer display?</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Are production lines scheduled off a single pacing process, with appropriate inventory levels at each stage?</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Is material moved only once and as short a distance as possible? Is material moved efficiently in appropriate containers?</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>13</td>
<td>Is the plant laid out in continuous product line flows rather than in shops?</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Are work team trained, empowered, and involved in problem solving and ongoing improvements?</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>15</td>
<td>Do employees appear committed to continuous improvement?</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>16</td>
<td>Is a timetable posted for equipment preventive maintenance and ongoing improvement of tool and processes?</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>17</td>
<td>Is there and effective project-manager process, with cost and timing goals, for new product start ups?</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>18</td>
<td>Is a supplier certification process - with measures for quality, delivery, and cost performance - displayed?</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>19</td>
<td>Have key product characteristics been identified, and fail-safe methods used to forestall propagation of defects?</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Would you buy the product this operation produces?</td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

**Total of yes: 7**

And from this answer, it is possible to obtain a table with the ratings for the facility. This tool helps to identify opportunities, and also to see how “Lean” a facility is. It is very important to keep in mind the background that was explained in the introduction to this study, in order to understand some decisions and situations about the management of this facility.
<table>
<thead>
<tr>
<th>Category</th>
<th>Related Q in RPA questionnaire</th>
<th>Poor (1)</th>
<th>Below average (3)</th>
<th>Average (5)</th>
<th>Above average (7)</th>
<th>Excellent (9)</th>
<th>Best in class (11)</th>
<th>Category score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer satisfaction</td>
<td>1, 2, 20</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Safety, environment, cleanliness and order</td>
<td>3 - 5, 20</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Visual management system</td>
<td>2, 4, 6 - 10, 20</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Scheduling system</td>
<td>11, 20</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Use of space, movement of materials, and product line flow</td>
<td>7, 12, 13, 20</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Levels of inventory and WIP</td>
<td>7, 11, 20</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Teamwork and motivation</td>
<td>6, 9, 14, 15, 20</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td>9</td>
</tr>
<tr>
<td>Condition and maintenance of equipment and tools</td>
<td>16, 20</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Management of complexity and variability</td>
<td>8, 17, 20</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Supply Chain integration</td>
<td>18, 20</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Commitment to quality</td>
<td>15, 17, 19, 20</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td>7</td>
</tr>
</tbody>
</table>

Once this information was gathered, and the processes where identified with their average process time, a model of the facility was constructed in a simulation program, in this case was used Extend. This was performed to give validity to the program and to see how the production was behaving, and from there being able to try the modification that will be suggested from the analysis.

The simulation confirmed the results that were obtained from the facility, the direct information that was taken at the shop floor, the average time for a product to go from the raw material stack to become a delivered good is 34 days, and the model showed how a lot of WIP
got stuck due to the fact that the bulks where not made right away. Also it showed how the flow in the line was disrupted in between the sewing process, where the closing is performed, and the weighting of the pillows, showing a length of waiting products that is going up at a rate of 3 pillows per minute.

![Figure 4. Extend model. January 15](image)

The model was constructed to look exactly the same as the VSM, making it very easy to follow, and to understand in which part of the process the company was having problems, in order to identify clearly where it was important to improve.

### 4.3. Data analysis of the current state

From the data showed in the chapter 4, it is possible to see that the facility was having many problems, and its level of leanness is almost zero. The facility had problems with the handling of the materials, making it very difficult to know and understand which products where needed, or how many products were in the facility. The inventory control was messy.

The facility was disorganized and unclean, sometimes affecting the final product because if it gets dirty it becomes scrap, even though it was very difficult to have a clear number regarding this, due to the lack of measures and metrics in place, it was possible to notice it when walking the production line.

It is also important to mention that when the customers visited the facility they were welcomed, and had a guided tour through the factory, and different things where discussed, there was a big motivation towards explaining the situation. Especially due to the fact that the company was behind in their deliveries, and many times the customer’s complaint, so they
treated them carefully and with a dedicated attitude in order to make them understand that it was something that they will overcome. But what happened in reality is that many clients decided to go and look for another supplier.

The problem with the general disorganization affected hugely the scheduling, in all the areas of the company, the cutting did not cut what was actually needed, and because it was outsourced and the communication was broken with the outsourcing company, in terms of explain the priorities, the facility received from them what they had finished, which many times did not matched what was needed or was urgent to produce.

Then of course the production line produce what they had instead of what was needed, the system was absolutely push, and many times not even pushed by the decision of the control room, but from what was delivered by the outsourcing company. And this generated an overproduction of finished goods that where unnecessary, and an underproduction of the ones that where asked by the clients.

The level of inventory was to high in some products and low in others, as it was explained before; and also a big amount of WIP was cumulating due to the fact that the production was not finished at once, but instead was a batch system, and until the batch was not finished the bulks where not done, and the individual pillows rested in the shop floor factory, many times until the next day.

The management of complexity and variability was very poor, the company actually seemed to have zero variability, even though the production process does not has to confront a big complexity, the family of products is just one, and the changes are so small that it does not even affects the times of production.

Also it is important to analyze the issue of sharing employees between different stages of the production process, these created huge amounts of WIP, specially of products waiting to be grouped in the bulks, but what was more important is that these movements were not scheduled, it happened randomly, or at any moment, or when they noticed a stock out of cuts, and of course this introduce uncertainty in the system, and some anarchy because it was very difficult to understand or to know when the line was going to be incomplete. When this happened due to loading the trucks, it was less traumatic for the process because when the
employees came back to the line they kept the bulks formation and because it is not a bottleneck process they normally catch up with the production line.

The supply chain is not integrated at all, because the company does not shares information throughout the supply chain, they just receive the products, there is no consultation. This might seem inappropriate, but regarding the country economical and political situation it has its logic behind, at least regarding the 2 raw materials, the fabric for the cover and the fiber for the filling; during the last year the company suffered a 3 month stock out of materials, and this was due to the country situation, where the foreign money is not possible to buy, and there is a big problem with the permits process and this caused the market to be without the raw materials for a huge amount of time, almost taking the company to bankruptcy, that is why they have a policy to fill up the storage with those two raw materials, and this of course that affects the through put time of the facility, but is a necessary evil in this specific case.

Regarding the material handling, it was a poor situation in the company, first of all the finished goods did not had they place in the factory, they were placed anywhere, making it very hard to have an inventory control, and in order to have a Lean facility it is necessary to have a good inventory control in order to know when and what to do something (2); also the covers did not had their position, and the place where the individual plastic bags where kept was far from the production line, wasting time in the process of moving them.

The facility had a very good and stable flow, but instead of having the finished products next to where it is dispatched or where they are storage, the finished goods ended up in the middle of the shop floor, having to move them in order to store them. This added wasted time to the whole process, and made an unnecessary movement of the product inside the factory, and also being in the wrong place for a while until they were placed in their storage area.

**4.4. Measures proposed. Simulation analysis**
After analyzing the situation of the company several measures were decided to tackle some of the mayor problems, the ones that jumped right away a causal of the huge delivery problems:

i. Implement a 5S program; it was important to not make the 5S program look as a saver, but as a part of the day to day activity. Some training and talks with the labour were needed in order to make them understand.

![5S Diagram](image.png)

Figure 5. 5S

ii. A system for the placement of the finished goods was design and built. This allowed improving the inventory control.

iii. The sewing of the cut covers process was brought in house. This will save time and also will help to know what is being sewed. Also a place for the folded covers was designated and placed next to the position where they are used in the production line. This step will include the hiring of 3 new employees, 2 for the sewing process 1 and one that will be working unfolding the covers. Before this will be actually implemented in the facility some trials were performed in order to understand the implications, in terms of space, time and logistics for the facility, this results will be showed and explained after the measures.
iv. About the process, it will be organized in a way that the individual pillows will be grouped in the bulks and placed in their assigned space right away, not leaving them there.

v. A layout modification was decided, the process now will finish next to the storage area, and because now the bulk will be formed right away, they will be moved a short distance until their new storage area. This will allow a better flow of the process, and reduce the WIP that was left in the shop floor, which was also a risk for the company.

vi. A scheduled system was placed in order to regularize the cuts and the moments when the process was incomplete due to the sharing of the employees between different areas. This schedule design established the production time form 7:00 am until 1:30 pm with the line complete, this will include the placing of the bulks in the new storage area, and from 1:30 till 3:00 pm the line will produce cumulating the pillows at the end of the process while 2 employees go and work with the cuts, this will allow the process to have the 2000 cuts needed for each production day, looking for the continuous flow, and avoiding the accumulation of WIP inventory, then from 3:00 until 4:30 (the closing time) the rest of the employees will dedicate their time to make the bulks and place them in the storage area, avoiding leaving WIP in the shop floor and also eliminating the hazardous situation that this implied for the facility.

In order to have a clear view of the impacts of these measures over the facility, a VSM future state was preformed, and the following figure shows it (in order to see a better picture see appendix B Drawings):
In order to obtain the data for the sewing process 1, which consists of two sewing machines in sequence sewing the fabric (that is why we see in the Table 4 sew 1 and sew 2), and the unfold of the covers it was necessary to perform some trials, in terms of space and logistics the process had no problems, and did not disturb the usual process. Regarding the process time the results were as follows:

Table 4. Cycle Times Sew 1 + Unfold

<table>
<thead>
<tr>
<th>Process</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>Ave</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sew 1</td>
<td>6.76</td>
<td>6.45</td>
<td>7.58</td>
<td>7.21</td>
<td>9.09</td>
<td>5.8</td>
<td>7.02</td>
<td>7.09</td>
<td>6.55</td>
<td>7.7</td>
<td>7.125</td>
</tr>
<tr>
<td>Sew 2</td>
<td>13.65</td>
<td>9.8</td>
<td>7.5</td>
<td>5.42</td>
<td>5.91</td>
<td>7.89</td>
<td>6.79</td>
<td>7.3</td>
<td>8.76</td>
<td>8.4</td>
<td>8.142</td>
</tr>
<tr>
<td>Unfold</td>
<td>12</td>
<td>15.69</td>
<td>13.8</td>
<td>11.48</td>
<td>16.78</td>
<td>13.5</td>
<td>14.85</td>
<td>14.1</td>
<td>13.9</td>
<td>14</td>
<td>14.01</td>
</tr>
</tbody>
</table>
Once these cycle time were determined, a simulation analysis was performed, in order to have a better picture of the functioning of the facility, and sees the impacts in terms of WIP, and finished goods, and sees how it will affect the deliveries and the backlogs compared to the current state.

![Figure 7. Extend Model Future State. February 25](image)

This new Extend model only incorporated the process of the Sew 1 plus unfolds when compared to the previous model, and also the scheduled that was designed for the production process and the sharing employee’s situation, regarding the bulk formation and the cut process.

When analyzed this new model it is possible to see how the flow in the process is much smoother, there are no stock outs or stoppages due to the missing of unfolded covers for the loading of the pillows, when having a mix production situation, even though the process is still a push model.

Also the flexibility is increased, there is a better control of what is being produced and what is needed from the cut process, it is possible to make changes in the production process, quickly and without the traumatic impact that the facility used to have. This is a key factor when presenting this option, because as it was explained in the market position, in the previous chapter, there are many last minute orders, that need to be delivered immediately, so an Make To Stock system is needed, and many times it was impossible because there was no possibility of changing the production program due to the fact that the covers where not made in house, and the facility needed to wait for them to come.

When we compare the throughput time of the two VSM, the current state and the future state, there is also a significant difference, there is a reduction of 9 days for a raw material to go through the whole production line and arrive to the customer’s hands (see
appendix B drawing to observe the difference), this reduction is a very important factor to push the implementation of these measures in the facility, because one of the biggest problems was the bad service given to the customer’s which was making them to change the company for any other in the market that offered a better service.

When analyzing the Extend model it is also possible to see how the facility now is capable to produce what the customer needs, but as it shows a huge amount of product accumulates in the facility, this means that the finished goods inventory is now a problem, because there is not enough space, this shows that the facility had a hidden capacity, that was there, but due to the organizational problems and the lack of flow for the process, a lot of time was being wasted, in terms of movement of material, and the late formation of the bulks, also the problem of identifying the goods, and how this affected the process of loading the trucks.

The model showed that in order to have a better flow it was needed another employee at the production line, making the flow better, this employee was placed at the punch seal sector, avoiding the accumulation of WIP in that place, and also improving the utilization of the bulk formation process from 0.55 to 0.87, which means that more bulks are being completed and placed in the storage.

Also the model showed how the bottleneck, as a facility, was moved from the production part to the delivery, with this modification, is now the delivering where the company is slow, or slower compared to the rest, meaning that not anymore the facility will have the trucks waiting for the products, and this means that the utilization of the trucks now will be higher.

Once these results were obtained, and showed to the staff in charge of the facility, and the director in charge of the company, they approved the implementation of these measures.

4.5. Results. Impact to the production process and delivery

The measures decided were implemented gradually, and in a logical sequence. First the 5S program was put in place. The Sort phase allowed identifying a great deal of finished goods that were going around in the facility; also it showed the employees that there was a mess,
something that they were not aware, even a denial situation was present. Once the products were identified the Straighten phase helped design a better system for placing the raw material, the finish goods and the WIP that will be generated, this phase incorporated into it the second measure that decided to put in place, which was to create a better place for the different items in the shop floor, this measure result will be discussed in greater detail next.

Then the Shine phase came into place, we were now able to clean the facility, to take away all the things that the facility did not use, and to see how a great deal of space was gain, now the factory even looked empty. When the Standardize phase came in, there were big problems regarding this, because the company did not had a standard guide, or some written standards, they actually work based on experience, and this goes well because all the employees are experienced, and there is not much sophistication around the activities, but when the new employee was hired it took some time to train him, and I strongly believe that a standardize guide or something that is written will help to soften the process of adaptation, this part of the 5S program was a failure, and it was very difficult to create the guide, even though there is a standard procedure and they use it, the feeling is that it depends too much on the employee and less on the “right way to do it”.

The sustain phase came nicely due to the great involvement of the employees and that they understood and notice the improvements on the shop floor. In the book The Lean Toolbox, the authors recommend to not make the 5S program look as the panacea or the ultimate solution, because then they will use it every time thinking that it will fix everything, and that was something that was taken into consideration, not even the 5S name was mention, or said as a program, to avoid generating the feeling of it as a program instead of a day to day way of proceeding; but each step was used and put in place, and it brought great results. A great deal of sensitivity was always around this implementation, because the employee’s were very susceptible to believe or feel that everything was done poorly before and it diminished their confidence and attitude to towards their work.

As it was explained before, the Straighten phase leaded to the second measure that was decided, the design and construction of a proper storage area. The design was a supermarket style area, where the products were separated, and a standardization of the number of bulks
that will be placed. The construction was simple, and only took 10 days to be ready. Once it was ready the areas where assigned to the different products, and by that having the finished goods inventory was very simple, it took few minutes to have it, instead of a whole working day of the cell supervisor, which was a big waste of time, but due to the disorder it was necessary to know what the factory had.

The results and the impact that this measure brought to the company were very positive, shortening the time to load the trucks, avoiding over production of some items, and improving the flow, also making it more obvious for the employees that leaving the sealed units in the floor was absurd when now they had a specific place to put the bulks, so this also helped to improve the Visual management of the facility.

Bringing in house the process of sewing the cover cuts plus unfolding of them, was important to lower the throughput time and also to gain flexibility. First it was needed to find the proper place in the factory; this was not so difficult because the 5S program generated some free space in the shop floor, this new layout will be shown next because it is a measure itself, which was perfect to place the process in house, without having the processes to close to each other or having the feeling of lack of space.

Having this process in house impacted in a great way the process, the flow was much smoother, and the flexibility gained by the production line helped to have a better service for the customers, it also allowed responding better to sudden orders. This reduced greatly the throughput time.

Making the bulks right away as the standard procedure gave great results, because the WIP was reduced a lot, the finish goods per day were also incremented. But getting it to be part of the system was very difficult, the employees were accustom to the old process and it was difficult to inculcate the new idea, it took at least 5 days to have the first day with the shop floor free of sealed units going around, but after that they understood the advantages. Also it gave a better understanding of what was made, and it was easier to control the production in the facility, avoiding over production or over stocking the factory with finish goods.

Once the facility was organized, the sewing plus unfold process was brought in house and there was no units around as WIP, it was possible to design a better layout for the factory.
The new layout (see Figure 8) helped to reduce the movement of material, the units where put together as bulks next to the storage area, having a more logical flow and helping it to be. This new layout improved the flow. Also with the new layout the throwing of the products disappeared, this helped with the problem of the fiber getting out of the unclosed pillow, and also because now the distances are shorter it helps increasing the quantity of products finished, due to less distance to go.

It is clear to see in the figure above (for greater detail see appendix B drawings) that the factory looks neater, and the space is better used; even in this plant map it is obvious the advantage of having a better organize shop floor.

The schedule of production was only implemented once the new layout was constructed and after the employee’s understood that the bulks needed to be completed and stored right away; and it brought great results, first of all the productivity increased in terms of finished goods, and also the employees had a better working rhythm, because somehow now they knew when they were producing, and how things were going to be done.
All the measures implemented brought great results to the factory, and even though that at the beginning there was some resistance from the work force at the end they prefer the new system, with the organized warehouse, with the fixed schedule for production, and they did not complain that much when there was a late order and they need to make late changes, and vary the product, actually it was totally the opposite, they felt great pride on being able to comply with that customer; it was like they were saying “we don’t care, we are capable of managing that”.

In general all the measures applied resulted in improvements to the facility, it allowed more flexibility and an increment for the customer service in terms of complying with what they asked in terms of delivery date and product quality; the product quality improved with the improvement of the production flow, less scrap due to dirtiness or disorder, which sometimes placed finished goods in the wrong place where it got damage.

The measures improved the facility, made it look neater and now we are even inviting the major customers to visit the facility in order to show them how we work, and how serious we are, something that never before was done.
5. MARCH 20. CURRENT STATE, ANALYSIS AND SCHEDULE FOR LEAN IMPLEMENTATION

5.1. Current State

Once the measures that were implemented were in a stable situation, and were actually part of the day to day routine and way of working, this next stage started. The first thing to do was to repeat the steps performed before in order to obtain the current state of the facility under the new parameters. Of course the new current state will be very similar to the future state generated before, but it will be checked due to the possibility of a change in the system because of the new working system, and specially schedule for the processes that was designed and implemented.

The Read a Plant Assessment technique (6) was performed in the facility again, but of course with the new plant situation, the results were as follows:
<table>
<thead>
<tr>
<th>#</th>
<th>Questions</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Are visitors welcomed and given information about plant layout, workforce, customers, and products?</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Are ratings for customer satisfaction and product quality displayed?</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>3</td>
<td>Is the facility safe, clean, orderly, and well lit? Is the air quality good, and are noise levels low?</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>4</td>
<td>Does a visual labeling system identify and locate inventory, tools, processes, and flow?</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Does everything have its own place, and is everything stored in place?</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>6</td>
<td>Are up-to-date operational goals and performance measures for those goals prominently posted?</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Are production materials brought to and stored at line side rather than in separate inventory storage areas?</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Are work instructions and product quality specifications visible at all work areas?</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Are updated charts on productivity, quality, safety, and problem solving visible for all teams?</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Can the current state of the operation be viewed from a central control room, on a status board, or on a computer display?</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Are production lines scheduled off a single pacing process, with appropriate inventory levels at each stage?</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Is material moved only once and as short a distance as possible? Is material moved efficiently in appropriate containers?</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Is the plant laid out in continuous product line flows rather than in shops?</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Are work team trained, empowered, and involved in problem solving and ongoing improvements?</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Do employees appear committed to continuous improvement?</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Is a timetable posted for equipment preventive maintenance and ongoing improvement of tool and processes?</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Is there and effective project-manager process, with cost and timing goals, for new product start ups?</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Is a supplier certification process - with measures for quality, delivery, and cost performance - displayed?</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Have key product characteristics been identifies, and fail-safe methods used to forestall propagation of defects?</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Would you buy the product this operation produces?</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

Total of yes: 12
Table 6. RPA. March 20

<table>
<thead>
<tr>
<th>Category</th>
<th>Related Q in RPA questionnaire</th>
<th>Poor (1)</th>
<th>Below average (3)</th>
<th>Average (5)</th>
<th>Above average (7)</th>
<th>Excellent (9)</th>
<th>Best in class (11)</th>
<th>Category score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer satisfaction</td>
<td>1, 2, 20</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Safety, environment, cleanliness and order</td>
<td>3 - 5, 20</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Visual management system</td>
<td>2, 4, 6 - 10, 20</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Scheduling system</td>
<td>11, 20</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Use of space, movement of materials, and product line flow</td>
<td>7, 12, 13, 20</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Levels of inventory and WIP</td>
<td>7, 11, 20</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Teamwork and motivation</td>
<td>6, 9, 14, 15, 20</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>7</td>
</tr>
<tr>
<td>Condition and maintenance of equipment and tools</td>
<td>16, 20</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Management of complexity and variability</td>
<td>8, 17, 20</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Supply Chain integration</td>
<td>18, 20</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Commitment to quality</td>
<td>15, 17, 19, 20</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>7</td>
</tr>
</tbody>
</table>

The company was running smoother; the total finished products ready to be shipped is 2000, the number of backorders in terms of finished goods is zero but the delivery of these products is slower than the production, meaning that the bottleneck of the company shifted from production to delivery, the facility now has an increased capacity, and this represents an increase flexibility, and by this it is possible to respond to late orders, which is a necessity due to the characteristics of the market.
This is possible to be seen in the VSM that follows, to see it better go to the appendix B drawings:

![VSM Current State](image)

Figure 9. VSM Current State. March 20

5.2. Analysis of the Current State

The current state of the company, Almohadas Cabanna C.A., at this point is much better than when this project started, even though the way to achieve a Lean facility is still very far away, the journey has started.

As is possible to notice the facility has improved in several areas when we see the results of the RPA technique (6). The rating for the customer satisfaction has improved...
compared to how the company was in January 15, this is due to the fact that the company now has the trucks all the time making different dispatches and never waiting without having the products to fulfill the order. The bottleneck of the company has now shifted towards the delivery department; regarding this the company needs to work on improving the system to assign the routes for the trucks and how the customers receive the delivery.

Another issue with the deliveries is the fact that many times the company does not know the real situation of the customer, and because of that sometimes orders that are somehow urgent or priority aren’t schedule as that, and then the customer cancels the order, generating a disturbance in the system, and of course making the company lose money and time, and in the worst case even the customer.

Also due to the fact that the market works with last minute orders, and it is very difficult to work with the customers to modify this, it is necessary to have a finish goods inventory that is able to absorb this situation, even though this goes against the lean principles, but what is necessary is to design a finish goods supermarket.

Regarding the safety, environment, cleanliness and order there was a significant improvement when compared to the situation in January 15, in the facility the products now are easy to see and to identify, and the products are being treated with a better care, thanks to the layout modification, and the placements of the processes closer, which avoided the throwing situation.

The plant is much cleaner and better organized, but there is still much room for improvements, there is still some dirtiness in the shop floor, and the loading process still generates a lot of dirty, letting part of the processed fiber to be in the shop floor, sometimes compromising part of the material because if it get dirty it is not usable anymore. The air level is very good, and also the usage of masks is now obligatory, as part of the standard procedure, something that before was obligatory but not implemented in practice.

The visual management improved in general, but still is far away from what the goal should be. The company now has an understanding of what is happening in the facility, and some processes are possible to monitor easily and directly; also now is possible to know what is being made. The facility still lacks of many metrics, the company does not traces the
productivity or how are they in terms of backlogs, or if they are delivering on time; and this makes very difficult to assess the performance of the facility.

In order to improve this part, an excel workbook was developed to be able to compare and see if the facility is improving due to the changes, this was done in parallel with the analysis, as an extra to this study, but because it was a key element in order to understand how things where behaving to a previous state, this workbook recorder the production and the dispatches since January 15, but is impossible to compare to any data from before, because there is none. This was an extra to the master thesis intention, but it will help a lot the company to monitor their behavior and to understand what they need to keep improving.

Once this was said, it is possible to understand that there were no charts or data posted anywhere, the company was lacking of a proper data collection.

The scheduling system of the facility now is a bit better because it only communicates to the pace process what is going to be performed, and it is related to what the facility needs to do to complete an order based on what there is of finished goods, something that before was very difficult due to the fact that the facility did not had an inventory control system in place, and that the only day when the inventories were known was on Fridays, and this makes it very difficult to know what was needed to do, and also this disturbed the process of taking orders because the sales department did not had the right information.

This was improved because now the facility is better scheduled, with a system mixture between a MTO (Make to Order) and a MTS (Make to stock). But it is still far away from having a better scheduled system, were the customer need is what prevails in order to trigger the production process, or to implement a Kanban system that will help to make only what is needed, the facility still struggles with overproduction, making what is not needed; regarding this point there is a mentality problem that affects, due to the changes performed before, now the facility is ahead of the order, meaning that now there is some idle time, where the facility is not producing, and this makes them feel that the company is not producing, and adding the problem of not having data to compare they cannot see that they are actually delivering the same amount monthly, just that they are employing less time, which could be used in other activities, or if the sales increases they are capable to fulfill that need.
Due to the fact described before about the idle time, the facility has incurred in generating a lot of covers, of the six different sizes, believing that by doing this they are advancing in something, without noticing the problems of building up inventory, because if a product is modified, the covers will be useless then, or a huge amount of rework will be needed, but this is something that happens due to the mentality explained above.

The use of the space in the facility is now much better than before, because now the materials are properly placed, they have their space and they are being placed in their specific place. The design and implementation of a storage facility and space for the finished goods, has help to understand and know what is being done, and if the facility is running low in some goods, and if something is missing.

Also with the layout modification the space now seems bigger, and there is plenty of room if the company wants to expand their activity; also the movement of materials is much shorter than before, and the finished goods now are being done next to their storage position, which has shortened the time spent moving them. Also by having the space well divided and specifically identified it is much simpler the truck loading process than before, because is much easier to count the number of products and to verify if the right amount was loaded.

But the facility still needs better space situation, for example the individual bags for the pillows are stored far from the position in the production line where they are used, wasting time looking for them and bringing them. Also the movement of the fiber rolls and the fabric rolls is not being done in the best way, and it is a very slow process.

The product line flow was dramatically improved since the process of sewing the cuts was brought in house; this helped to have what was needed, and also achieved a better flow and also the modification of the process with implementing a bulk conformation right after the pillow units were sealed achieved a improved flow, there were no stoppages because there was too much product around, and the line had a better continuous runs, even though there was a product mix running in the production line.

The levels of inventory before the measures implementation where messy and difficult to know and estimate, and because of this huge difference the rating was increased a bit, just one level better, but it still needs lots of improvement in order to achieve some Lean degree,
the facility still produces in a push fashion, and because of this the levels of inventory are high compared to what is actually needed. The facility is capable to produce 2000 units per day but meaning that they can produce 10000 units a week, and the dispatch average per week since January 15 is around 7500, which means that due to the push system the inventory is built up, and too many finish goods are in the storage.

Due to the reality of the country, the raw materials have a special treatment; this is the only inventory that has to be kept high, even when the facility knows that it will keep piling up, but because of the economic and political situation, it is necessary to do this in order to avoid possible stock outs of the raw materials in the market, and by this any company that was better prepared for this will take the market, and after that it will be very difficult to recover the lost territory.

It is very important to generate a combined solution for the schedule of production and the level of inventory, in order to reduce the overproduction problem, and by that the level of inventory will also be reduced, and to educate the labour and the company employees to understand that there is no gain on working on something that is actually not needed, foreseeing a demand that has not being materialized, avoid the forecast process; instead try to follow the actual demand.

The teamwork and motivation of the company was the only rating that was downgraded after the measures were implemented; and this is because the employees, who in first place were very open and happy to see that they were taken into consideration for the system modification, had a change in their attitude because they started to be not collaborative, and instead of keep helping they started to feel that the new system will make them useless, so it was difficult to make them understand that actually it was something that will not only help them, and improve the company without jeopardizing any job position.

There was some relentless towards the new implementations, and when they were communicated with the possibility of having a new improvements schedule the fear increased, and they were not as helpful as they were before. This was a bit frustrating, but after many communications and talks throughout the plant workforce, they started to see the benefit and understand that no one was going to be sacked from their job place.
The condition and maintenance of equipment and tools is a rating that maintain its previous score because there was no measure that affected it, even though some comments about changing from an absolutely reactionary maintenance system towards a more preventive one, and some of the idle time that was mentioned before was used to give some maintenance to the machines and the facility, the mind-setting of the employees and the company is to give maintenance just when the equipment went down and then repair it, there is no preventive maintenance culture.

This system for the maintenance cause to have break downs in moments when the production needed to be running smoothly and at full capacity; this also help to create the conscience of having a huge inventory of finished goods, and is because of these situations that they cover their backs when a break down happens, instead of thinking that if they have a prepared maintenance program they will know when they have to perform a check to avoid a sudden stop of the production line. This is very difficult but important point to correct, but also the one that has more resistance due to a cultural approach to the problem.

The management of complexity was difficult to assess and judge in the first RPA assessment because the company has no recording of data, and also because the process is fairly simple, but there was no aid to help the employee to pick the right part, in this case was clearly notice regarding taking the right cover size and the right plastic bag, and this was due to a lack of information in the production line, the employees many times did not knew what product were they going to make. But in general, with the improvement of the use of space, the better location and the cleanliness that is now present in the facility, this area also improved.

The supply chain integration is an area of study that is difficult to assess, because in the Venezuelan market there is no much cultural attitude and understanding towards this. But some customers started to understand the benefits of the new system implemented at the shop floor level, due to the fact that the deliveries and the service level improved, and because of that started to share some information about their sales, and how they are doing.

The biggest customer of the company has implemented and EDI (Electronic Data Interchange) system, that helped enormously when planning the dispatches, because with that
it was possible to send what was actually needed, and also it helped to start generating a better view of what would be the right takt time for the facility, a concept that is key to any Lean implementation or movement. Also bringing in the sewing of the cut covers improved the availability of the trucks and by this the supply chain had some extra capacity that was being miss used.

The commitment towards the quality has being very high since the beginning. The employees are fully aware of the advantages of having a great quality, and that it will make the company gain terrain in the market by making a better product at a competitive margin.

Also due to the improvement of the flow, some quality issues that were hidden have arise, like the amount of bad plastic bags, or the fiber that is sometimes wet, due to bad deliveries, but those things do not downgrade the points given in this subject, because they were there, just that they were hidden and that is an advance.

Also the wastes that are described by Professor Liker in The Toyota Way (3) book were identified throughout the facility and the different processes, in order to see areas of opportunity to improve, and to design a first schedule for the path toward developing a Lean facility.

The first waste, and probably the most evident, and the one that causes many of the other wastes, is the over production, there is a big problem in terms of overproduction in the facility, the labour starts producing items without having a necessity to do it, they just have the need to produce, and this is because the cell supervisor has the need to be producing, because he feels that if the line is not producing they are wasting their time, or they are making something wrong; also the way they are being monitor is too production driven instead of being more interested on the service level or how the customer feels the company is making the deliveries or if the company is complying with its responsibilities towards the customers.

It is difficult to make the cell supervisor and the director of the company understand that having the line stop is better than producing something that is not actually needed. This over production generates a huge problem for the facility in terms of storage; there is not enough space, due to the fact that since the changes performed to the facility after the first assessment they are ahead of the delivery process. Also this affects the safety of the facility,
because things are started to being placed in the middle of the shop floor, generating some hazardous situations, but even when you explain them that it is a problem they do not understand why, there is a huge problem of mentality, of the way how they see things.

The time is not an issue for the facility; actually the only problem that is possible to see is the idle time that the facility is experiencing due to the improvement in the production process, and that the number of finished goods has increased significantly, from an average of 1500 daily to 2000, this has moved the bottleneck to the delivery process, and this makes the facility to wait in order to produce. Even though the facility is over producing they reach a point that not even over producing they can keep making the items, and there is some idle time, that the cell supervisor uses to produce covers, to have them ready to go into the line, generating again a problem for the shop floor because there is no more space to put things.

The slowness of the delivery process is generated due to the combination of two factors: the first is that the company dispatches to the whole country from the facility storage in Caracas, and the second is a mentality problem, were the delivery process is only allowed when the dispatch has a full truck, delaying orders, and failing to meet delivery date requests, because they thing that is not economical convenient, so the problem is that the company fails to understand the type of Supply chain that is best for their product (5).

The pillows are a functional item, and because of that the demand is somehow stable, and possible to recognize, and the life cycle is not as short as it is for an innovative product, so the important thing for this type of product, a functional one, is to be in the market, because the customer is not whiling to wait for it, they go to a store and they expect to leave the store with the pillow not to place and order and then go and pick the item (5).

The company needs to recognize this, and manage to elaborate a better delivery process, were the trucks are never delayed, and to understand that the hidden cost of not being at the shelf is much higher than the reduction of the delivery cost due to have a full truck being sent each time.

The third waste identified is the unnecessary transport or conveyance, which has improved dramatically since the current state of the facility in January, but there is still some issues regarding it. The placement of the individual bags far from the place in the production
line where they are used, making the movement in batches, and taking time for the operator to look for them. Also the placement of the rolls of fabric is far from the cutting table, and it slows down the process due to the unnecessary transportation. Also due to the overstaffing that is generated because of the overproduction the movement of the materials takes more time because the product is wrongly placed. But it is possible to state that this waste is the one with minor impacts and the one that is affecting the less to achieve a Lean facility. It is possible to reducing many of the movements, but at the present state they do not represent more than 10% of the production time.

Over-processing is not an issue for the facility, the processes involved are pretty simple, and they are not redundant. But there is some incorrect processing, in terms of scrap, and waste of materials, like plastic bags that are wrongly sealed and then need to be changed and some re-work is necessary. Also the process of loading the covers generates a lot of re-work, because the machine has a problem with the process, regarding some fiber that is being processed and it ends in the floor, generating a re-work, because an employee needs to pick the fiber from the floor and feed the machine again in order to use that fiber.

The excess of inventory in the facility needs to be analyzed carefully. Regarding the fiber it is understandable that the company has an excess of inventory, because, as it was explained before, the country has a problem with the flux of foreign money, and because this raw material is imported when they have the possibility to import they need to do it, it does not matter if then they will have an excess of inventory, but due to bad experience in this matter, which led to a stock out of the raw material, having then to stop the facility, the company has a policy to buy whenever is possible no matter that they have too much.

In terms of finished goods, it is problem to have a lot of them as inventory, because they can be ruined if there is any problem in the company, heavy rains in the country is an issue and sometimes because of that the sewage system of the streets is not capable of manage the amount of water that comes down in the rain, and this represent a hazard for the company because it can suffer from flooding, actually it happened once during this master thesis, and because it was not that big of a flood the finished goods did not suffered, but having them...
there could mean a loss of money. Also this excess of inventory becomes a problem to the movement of materials and the employees, and is a safety issue.

In terms of unnecessary movements, there some issues with the ergonomics and moves that the employees need to perform in the production process, but because disclosing this information represents a problem for the company, this master thesis will limit to just inform that there are some parts of the process that have wasted movements, that there is an issue with stacking some WIP in the production scheme. These wasted motions can represent even 30% of the time, and is a huge hidden waste, that the company needs to work with.

There is a low percentage of scrap, and damaged goods, there are more related with a process issue that was described before. There is a problem in the company with the way of recording these, because they do not keep a clear and good track of scrap, it is there, but there is no point of comparison, and this is a big issue in terms of control, but due to the fact that during this study the scrap represented less than 1% of products being processed it is not carefully analyzed, but we strongly recommend that in the future it is better analyzed and considered.

The unused employee creativity is a waste that is very difficult to assess, and to explain how it goes; but it is possible to say that since this study started the employees have being asked to participate and to give their opinions, to take into consideration what they think and feel about the process. Something that from the reaction and comments was never done before, so it is possible to say that the company was losing a great deal of their employee’s ideas to improve the process and the system as a whole.

Thanks to the excel workbook that was created, as it was explain above, we are now able to calculate the takt time (4) that the facility needs to work, and this was calculate as follows:

\[
takt\ time = \frac{\text{available working time}}{\text{customer demand}}
\]

the average customer demand during the first 3 month of this study was 25500 units, and the available working time per shift based on the new schedule that was implemented is 21600 seconds, having then as a result a takt time of:
\[ \text{takt time} = \frac{21600 \text{ sec}}{1250 \text{ units per day}} = 17.28 \text{ sec per product} \]

This is the time that the processes need to comply in order to meet the average customer demand. It is important to keep in mind that this time does not take into account the downtime of the machines, or the changeover time.

5.3. Measures proposal. VSM Future State

After analyzing the current state of the company in March 20, a measurement proposal was started in order to achieve a leaner facility, with the goal of a significant lead time reduction, which was one of the major issues of the company, something that as its being describe before was making them lose market share against the competitors due to many backorders and a very poor service, that even though was improved in the first stage of this master thesis work, it is still very low, and could end in a bigger market share to be lost, maybe at a lower speed but still meaning a backward situation.

In order to generate a future state value stream map that will be leaner, it was decided to use as a guideline the book learning to see (4); were the authors recommend asking eight questions that will lead to improve the facility in a leaner way. In this recommendations this eight questions are taken into account, but as all the literature says, each case scenario is different so it is important to adapt to your reality.

i. The first key element is to have a facility that works towards achieving the takt time, this is the time that each part or process involved in the facility need to comply with. It is important to note that the company has an advantage towards this lean transformation due to the initial improvements, because they are working at a rate that is faster than the takt time, meaning that the company has a spare capacity in the production area that will allow making some changes in order to improve the existing flow or generate it. This situation simplifies a bit the application of the changes because the company has the idle time needed to get used to the modification that are proposed.
Having this advantage is also a problem because as it is explained in the book Learning to See (4), having this gap in your favor evaporates the necessity to make the improvements, so it is necessary to take measures that will reduce this; in the case of this company what is being made is to improve the sales, increasing them, and improving also the marketing towards having more sales, this will reduce the takt time because the time available will be the same but the customer demand will increase, and of course this will close the gap.

ii. Introduce a combination of MTO and MTS system: Due to the market characteristics, having a system that work with an MTO (Make to Order), meaning that is directly to shipping is not possible, because many times there are late and urgent orders, that have to be sent right away, and there is no time to make them, so a supermarket of finished goods will be placed, design to buffer this situation.

The procedure will be a pull with MTS system, where the Process Control send the orders directly to the shipping department, whom will take the products needed from the supermarket of finished goods, and this will trigger a Kanban system in order to replace the products (See Figure 10).
Also it was placed some Kaizen burst referent to the shipping process, first it will be necessary to improve the process of loading the truck, because as it is performed nowadays it takes too much time, and is not a standard procedure, which makes very difficult to know in advance how many product will fit in the truck, and how they will arrive to the customer; it represents a quality hazard, and needs to be checked and improved. It is necessary to work together with the customers, in order to reduce the amount of sudden orders, and by that the target stock at the supermarket of finished goods will be reduced and possibly eliminated in the future, working absolutely with a Make to Order system.

iii. Create flow where it is possible: The facility needs to introduce flow as much as possible in order to reduce the WIP, and by that reduce also the overproduction problem, which is a huge causal of the high lead-time that the facility is
experiencing. With the introduction of FIFO lanes systems in between the processes, the worker will not work in a batch mode, will make the first product that arrives right away. In order to achieve this, the new layout implemented in the first part of this study was very useful, because the employees are closer to each other and they are in a sequence, the distances are short, and they can almost give it to each other’s hands. It is possible to see this in the following figure:

Figure 11. FIFO system between the processes. Flow improvement

Also in order to improve the flow, it will be necessary to improve some material handling aspects, for example it will be needed to have a better system for the individual plastic bags, a new shelf for them, right at the production line, next to where they are used, probably a supermarket for them, this will reduce greatly the change over time of the activity, because instead of go and bring them they will be there.

iv. Pull systems: three pull systems were implemented throughout the process replacing the push systems. This will improve the responsiveness of the facility, also helping to reduce the overproduction and overburden of the employees and machines. This will also help to reduce the WIP present in the facility, and the problem of space related to the overproduction will be eliminated.

Two pull supermarkets are recommended, one between the first sewing station and the loading of the covers, which will increase the flexibility and the capacity to respond to sudden orders of the facility, and also will reduce the change over time; and because the cutting process is not very flexible, having this supermarket will lower the pressure on this process. Also pull is recommended to be implanted when taking the raw materials, even though they will still work
as inventories and not supermarkets, it will give the facility a better system, and handling of those materials. See Figure 12 and Figure 13:

The pacemaker: the process will have the pacemaker at the finished goods supermarket, because that is the most downstream process from where it is possible to send information and start pulling everything else, this will help reducing the overproduction, the unnecessary movement of materials, and also will help to have a better production load; due to the mix that comes with the orders, where the customers usually order from different products and in relatively small quantities, it is not necessary to introduce a forced leveling, the order as it comes is already pretty much leveled, so the line will simply follow what is needed to fill the target stock at the finished goods supermarket. Also because the changeover is not a problem for the line, since the supermarket for the cover will be functioning before.
vi. Kanban system: in order to favor the pull system in the facility, and to eliminate all the WIP inventories that were present a Kanban system will be recommended to be implemented through the facility. First there should be a Kanban system that will come from the finished goods supermarket, which will trigger the production process at the loading of the cover; this will come as a batch Kanban (see Figure 14). Then another Kanban system should be used to trigger the cutting process, because the system will have the covers supermarket, it is important to avoid scheduling the cuts that will be needed from a forecast, instead it will be better to follow the orders, and what is actually needed (see Figure 15).

Figure 14. Kanban system between the finish goods supermarket and the load
Figure 15. Kanban system between the covers supermarket and the cutting process

This second Kanban system will mix the number of covers taken from the covers supermarket and will send then the Kanban with an order of approximately 1250 units, each cover size will have a Kanban card representing 250 units, when the covers are taken the cards are moved to a box, when the amount of cards is equal to 5, then they are moved as one block to the cutting process, that is why in the VSM it looks like one Kanban card, but actually it is a combination of several, but due to the process it is impossible to work for such a small number as 250 units, so a hybrid system for this specific Kanban was designed.

vii. Process improvements: in order to be able to achieve all of the recommendations exposed before, there are some processes that need special attention, and those are exalted on the VSM as Kaizen bursts, meaning areas where it is important to work towards improvements. Improving the data exchange with the raw materials suppliers, in order to reduce the quantity being sent but increase the number of dispatches. Also the cutting process needs to be improved, in order to have a better flow in the area, improving the material handling and reducing the set up time, so it will allow more cuts per shift. Also the trucks loading process needs attention, at the moment it has many flows as it was explained before. Explain the advantages of the milk run delivery system to the customers, and also negotiate with them to have a better data exchange,
so the company can help them with the re-order point and how they manage their inventory.

Implementing this will transform the process as is possible to see in Figure 16 (to have a better understanding of the picture see the appendix B drawings). From the VSM the lead-time reduction will be significant, from 25.04 days to 9.571 days, a 38.22% of the previous time. Also this will mean that the total inventory turns in a year will increase from 9.58 to 25.08, which will be a 262.04 % of increment.

Figure 16. Future state VSM March 25

5.4. Schedule for the Lean measures implementation
The most important point about the future state implementation plan is not to think of it as implementing a series of techniques, but to envision it as a process of building a series of connected flows for a family of products (4).

In order to generate a schedule to implement the measures proposed before, we will follow the technique that is advised in the Learning to See (4) book, where the authors recommend to divide the VSM future state into smaller loops, that will allow to organize better the work, and to avoid improving something at the wrong time and by that lose the idea and the momentum.

The loops will be as follows:

i. The pacemaker loop: encompasses the flow of material and information between the customer and the pacemaker process. This is the most downstream loop in the facility, and how it is managed will impact in all the upstream processes (4) (See Figure 17).

![Figure 17. The pacemaker Loop](image)

ii. Additional loops: upstream the pacemaker loop there are material flow and information flow loops between pulls. That is, each pull-system supermarket in the value stream usually corresponds with the end of another loop (4)(See Figure 18 and Figure 19)
Figure 18. Process Loop

Figure 19. Raw Materials Suppliers Loop
Once these loops are clearly identified, it is possible to divide activities for the improvement of each loop. In each loop a series of activities are established to achieve the future state. In order to see a detailed schedule see the Gantt chart in the appendix C.
6. CONCLUSION

- Understanding the Value Stream of a company is a key factor in order to implement a Lean transformation.
- Overproduction was the biggest problem present in the facility, and also the most difficult to improve due to the mentality.
- Changing the mentality from a mass production point of view, were the most important thing is to reduce the item cost per time, by producing as much as possible in each process, to a more value stream improvement thinking, were the whole is more important than the isolate process, is a difficult task, that needs to be tackle since the first moment through careful training and explanation, especially with the operators at the shop floor level.
- Applying the Gemba principle, go and look was the most useful principle to put in practice, because it motivated the employees and also helped to understand better the labour situation and concerns, which was a key factor in order to attain the results in the first stage, and also to make the assessment for the second stage of the study. It also helped to gain the trust of the employees, whom at the end are the ones that will make the Lean transformation to exist.
- Avoid the resistance in the facility is very important in order to apply all the changes.
- Working closely with the supply chain, from the customers throughout the facility until the raw material suppliers, generated the most reductions in lead-time.
- Using the simulation tools was very important in order to convince the managers about the results that the Lean philosophy will bring.
- Applying Lean thinking to a facility improves the Lead-time, by reducing it, increasing the inventory turns, and also helps to improve the quality.
7. FURTHER STUDIES AND IMPROVEMENT AREAS

This last part of this master thesis is a recommendation for further studies that the company could perform in order to keep improving towards a lean philosophy.

- Develop a training program: the company needs to change the mentality, showing that producing a lot when is not needed is not a good decision, that having a machine always producing does not reduces the costs, it actually increases because then you have more WIP, which difficult the identification of scrap and increase the material handling problems.

- Understand that the metrics in a company are important, but also that the metrics use will guide the improvements, so choosing them is a key to success. I would recommend focusing on improving the service level, and keep reducing the lead-time.

- Work with the raw material supplier to show them that a milk run is better, that delivering a smaller quantity more often is better; and also to develop a better communication system, were the company is able to show them the inventory position and by that will be schedule the delivery. This should be performed with all the raw material suppliers and also with the plastic bag supplier.

- Once the data exchange is achieved, work to change the inventory situation towards a pull supermarket system, this will lower the lead-time and also increase the inventory turn, reducing the material handling and safety hazards, and increase the available space, which could be use to develop another business in the same space.

- Work towards improving the cutting process, this is also needed to generate the future state developed during the study, but is strongly recommended to keep improving it.

- Work towards eliminating the FIFO lanes, and instead have a one-piece flow, especially in the transition from the weighting to sewing the cover that were loaded with the fiber; this process still has a very batch style look, and is the
bottleneck of the production process. If the company achieves an increase of the demand, this will be the bottleneck, once the delivery capacity is increased.

- Introduce an ABC (Activity Based Costing) system, this will allow to identify which processed are the ones contributing more to the costs of the products, and by that an especial kaizen team could work towards improving them; keeping in mind the effect in the system as a whole, avoid islands of excellence.

- Work towards creating a cell that includes all the process from feeding the machine with the fiber until making the bulks, this also helps having the one piece flow.

- Work towards introducing a VSM manager or a person that is in charge of monitoring it (4), also creating Kaizen meetings to keep improving, and never stop the continuous improvement process, this is what will keep the company at the edge of the market.
REFERENCES


## APPENDICES

### A. Historical Data:

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B. Drawings:
   a. VSM. Current State Almohadas Cabanna. January 15
Customers

30,000 pcs/mo; Q ≈ 15,000, K ≈ 2,000, S ≈ 4,000, M ≈ 6,000, INF ≈ 3,000

Bulks:
- Q(10), K(5), S(14), M(12), INF(40)

Raw Materials

Monthly forecast

Weekly forecast

Process Control

Daily entailies

CELL SUPERVISOR

Weekly Cuts Schedule Forecast

Weekly Production Schedule Forecast

Cutting

1 x Month 150 rolls

2000 pcs

CT: 26 min
Set-up: 150m
10,800 sec
1 Shift

Feeding+Load+Weighting

4000 pcs

CT: 9.5 sec
C/D: 5 min
21,600 sec
1 Shift

Sewing2+Punch+sealing

2000 pcs

CT: 25.5 sec
C/D: 8 min
21,600 sec
1 Shift

Packing

4000 pcs

CT: 61.2 sec/bulk
C/D: 4 min
25,800 sec
1 Shift

Shipping

4000 pcs

CT: 10 min(staging) 150m (loading)
10,800 sec
1 Shift

Covers Outsourced

4000 pcs

CT: 20 min
15 days of fabric rolls

Leadtime 3 days

Cuts Outsourced

4000 pcs

CT: 25.5 sec
C/D: 5 min
21,600 sec
1 Shift

15 days

20 m

12.5 days

0.04 days

1 day

3.5 days

2 days

24.04 days

180 billspace: 5.4 days

Monthly (Forecast)

Weekly
b. VSM. Future State Almohadas Cabanna. February 5
VSM. Current State Almohadas Cabanna. March 20

Customers

30,000 pcs/mo; Q=15,000, K=2,000, S=4,000, M=6,000, INF=3,000

Bulks: Q(10), K(5), S(14), M(12), INF(40)

1xMonth 150 rolls

1xMonth 72 bulks

1x2 days 2,500 pcs

15 days of fabric rolls

Raw Materials

Cutting

CT: 20 min
Set-up: 15 min
10,800 sec
1 SHF

Sewing 1 + Folding

CT: 29.28 sec
C/O: 3 min
28,800 sec
1 SHF

Feeding + Load + Weighting

CT: 26.9 sec
C/O: 5 min
21,600 sec
1 SHF

Sewing 2 + Punch + Sealing

CT: 25.5 sec
C/O: 8 min
21,600 sec
1 SHF

Packaging

CT: 61.21 sec/bulk
C/O: 4 min
28,800 sec
1 SHF

Shipping

CT: 160 sec/bulk

Weekly

Monthly (Forecast)

Weekly Cuts Schedule Forecast

Weekly Production Schedule Forecast

Daily Priorities

CELL SUPERVISOR

15 days
20m
1 day
29.28
2.5 days
25.9 sec
25.5 sec
0.04 days
1 day
6.12 sec/pc
3.5 days
25.04 days
2 days
160 min
180,960 sec / 3.44 days

1 Shift
Customers
25000 pcs/mo; 
Q≈12000, K≈1000, 
S≈4000, M≈6000, 
INF≈2000

Bulks: Q(10), K(5), 
S(14), M(12), INF(40)

Improve the data exchange with the RM suppliers
e. Layout of the plant January 15
f. Layout of the plant February 20
C. Gantt chart Lean Transformation Timeline:

Schedule FS_VSM_Mar25.mpp