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Application of lean manufacturing tools for the improvement of production processes in the textile company Cheila CyC

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ABSTRACT*: Clothing as an industry has been revolutionized by the adoption of lean manufacturing principles. Among the tools used are those of lean manufacturing that seek to reduce waste and increase efficiency in manufacturing processes. This system has been applied to various industries such as the textile sector, which the rationalization of processes such as cutting, clothing and finishing. It begins with the identification of waste areas, classifying them into materials, time, and labor to analyze whether the different activities should be eliminated, replaced or merged to optimize the production process through cost reduction. Four work methodologies are selected starting the process with the 5's, the VSM, Smed and just in time. With the implementation of this methodology, it is possible to increase production by 30% and reduce raw material waste by 20%.*

KEYWORDS – *Lean manufacturing, VSM, textile, processes, waste*

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I. INTRODUCTION

Lean manufacturing is a methodology that provides different tools according to the needs of each company, aiming to improve production processes with small changes that, when added, generate big changes. These instruments seek to reduce waste either of materials or of times that do not contribute anything to the product.

To achieve the objectives, an in-depth study of the production information is carried out, which includes the organization of jobs, maintenance, internal production flow, among others. This seeks to change the culture of the company so that the production personnel adopt it thanks to the advantages and the work that is carried out through change management.

The first principle of lean manufacturing is to identify and eliminate waste. In product manufacturing, this may mean simplifying processes such as cutting, sewing and packaging. For example, by analyzing the cutting process, a clothing manufacturer can identify that it is using too much fabric or taking too long. By eliminating waste, you can reduce costs and improve efficiency. Plus, by optimizing it you can reduce the amount of fabric waste created, which is good for the environment.

The second principle is to focus on value, this means understanding how the customer perceives the product. This allows quality products to be created and waste to be minimized. For example, it can be identified that customers are looking for products made with sustainable materials. By focusing on this value, the manufacturer can create products that meet this need, while reducing waste in the production process.

The third principle of lean manufacturing is continuous improvement. In manufacturing, this means continually looking for ways to improve processes and reduce waste. For example, identifying that the sewing process is taking too long, and thus increasing costs. By continually looking for ways to improve it, the manufacturer can reduce costs and improve efficiency. On the other hand, it is important to keep up with the latest technologies and processes, which can help you to be competitive in the market.

At CHEILA CYC it has been shown that waste is generated in the existing processes. In cutting, the accumulation of imperfect fabrics as well as surpluses are a major problem since these are cost overruns for the operation and also represent a logistical problem since the accumulation of these generate the need to have spaces for their storage, which is a high cost for the company. Delays are showing in clothing due to the lack of organization in the way of delivering, which brings confusion, delaying production and presenting reprocesses.

In conclusion, the methodology can be applied to the manufacture of various textile products to minimize costs, increase efficiency and quality. By identifying and eliminating waste, focusing on value, and continually improving processes, manufacturers can create products that meet customer requirements while minimizing waste. In addition, by using lean principles, the impact on the environment can be reduced. In general, lean manufacturing is a valuable tool that seeks to keep organizations competitive in the market and create sustainable products. The objective of the project will be to develop lean manufacturing tools for the improvement of the different production processes and guarantee the deliveries of Cheila CyC to its different clients.

II. METHODOLOGY

In this study, a mixed investigation is carried out by combining qualitative and quantitative approaches for the development of the lean methodologies, being the primary basis for comparison and verification of the project's viability.

As a starting point, the verification and updating of the flowchart and processes which were modified with the first implementation activities of the 5's were carried out, allowing to generate the best locations for the materials.

With this information, we proceeded to determine which would be the lean manufacturing tools that would be applicable to the company's processes, determining its objective and comparing it with the improvement needs for CHEILA CYC.

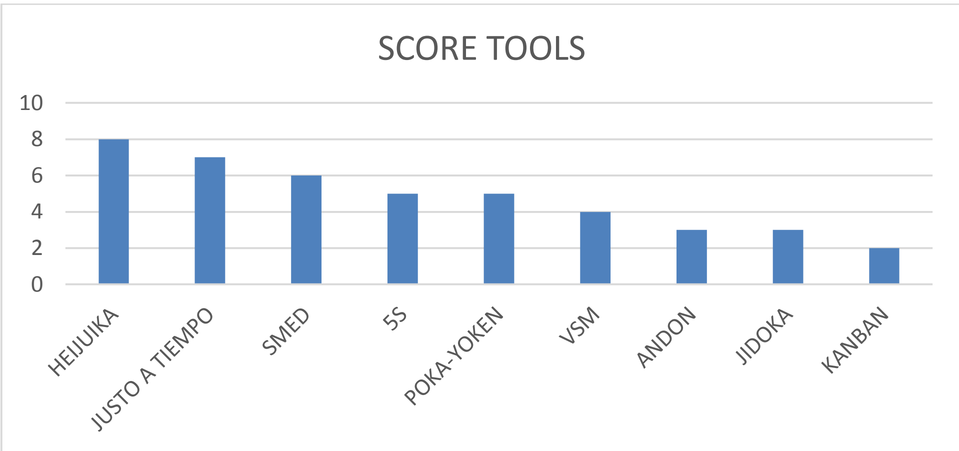
Table 1. Tools vs Needs

	There is no weekly capacity limit	There is no safety stock	Lack of standardization in processes	Excessive scraps in production	There is no stock of raw material	There are no quality plans.	lack of methodology in production	Looking for an international certification
5S			X	X		X	X	X
VSM	X	X	X		X			
KANBAN	X						X	
POKA-YOKEN	X		X		X	X		X
SMED	X		X		X	X	X	X
ANDON			X			X	X	
HEIJUIKA	X	X	X	X	X	X	X	X
JUST-IN-TIME	X	X	X		X	X	X	X
JIDOKA	X		X			X		

Source: The authors, 2023.

Table 1 shows the score for each tool, which is done through meetings with those responsible for each area and the general management of the company.

Figure 1. Comparative results Tools vs Needs



Source: The authors, 2023.

In figure 1, the results of the comparative study are shown, being Heijuika, Just-in-time, Smed,5s and Poka Yoken the tools with the best score. Based on it, the generation of different programs to apply such tools is developed.

Figure 2. Programs

STAGE	IMPLEMENTATION	TIME	RESOURCES
	HEIJUNKA IMPLEMENTATION		
STAGE 1	Determine those responsible and implementation schedule	1 WEEK	GENERAL DIRECTORATE
STAGE 2	Work Cells	2 WEEKS	GENERAL DIRECTORATE, PLANT MANAGER
STAGE 3	Continuous flow piece by piece	2 WEEKS	GENERAL DIRECTORATE, PLANT MANAGER
STAGE 4	Production adjusted to the Takt time	4 WEEKS	GENERAL DIRECTORATE, PLANT MANAGER
STAGE 5	Leveling of the amount of production	4 WEEKS	GENERAL DIRECTORATE, PLANT MANAGER
STAGE 6	Create indicators for evaluation and continuous improvement	2 WEEKS	GENERAL DIRECTORATE, PLANT MANAGER
	TOTAL		
	JUST-TIME IMPLEMENTATION		
FASE 1	Determine those responsible and implementation schedule	1 WEEK	GENERAL DIRECTORATE, PLANT MANAGER
FASE 2	Unify and evaluate the methodologies	2 WEEKS	GENERAL DIRECTORATE, PLANT MANAGER
FASE 3	Production Leveling	4 WEEKS	GENERAL DIRECTORATE, PLANT MANAGER
FASE 4	Client - Provider Relationship	4 WEEKS	GENERAL DIRECTORATE, PLANT MANAGER
FASE 5	Create indicators for evaluation and improvement continue	2 WEEKS	GENERAL DIRECTORATE, PLANT MANAGER
	TOTAL		
	SMED		
FASE 1	Determine those responsible and implementation schedule	1 WEEK	GENERAL DIRECTORATE, PLANT MANAGER
FASE 2	Evaluate the current state of the processes	2 WEEKS	GENERAL DIRECTORATE, PLANT MANAGER
FASE 3	Definition of objectives that are intended to be obtained with the SMED methodology according to the problem posed	1 WEEK	GENERAL DIRECTORATE, PLANT MANAGER
FASE 4	Assessment of the current situation (Enlistment and week cleaning)	1 WEEK	GENERAL DIRECTORATE, PLANT MANAGER
FASE 5	Decompose the change of tools into elementary operations, once the elementary operations have been identified, it is necessary to separate them into internal and plant external, measure change.	2 WEEKS	GENERAL DIRECTORATE, PLANT MANAGER
FASE 6	Analyze the causes, determine the real functions of each operator. Transform internal operations into external ones, ideas are proposed to rationalize the remaining internal operations and the operations external	2 WEEKS	GENERAL DIRECTORATE, PLANT MANAGER
FASE 7	Apply the improvements. A detailed action plan will be established, carry out the different technical operations that have been programmed in it	3 WEEKS	GENERAL DIRECTORATE, PLANT MANAGER
FASE 8	Standardize the enlistment process, all aspects of the encapsulation operation are perfected	3 WEEKS	GENERAL DIRECTORATE, PLANT MANAGER

Source: The authors, 2023.

Figure 2 lists the programs that were chosen along with the estimated times for their implementation and those responsible for each one, among which are:

5S, is a methodology used for organizing and maintaining a clean and efficient workspace. The 5S stands for Sort, Set in Order, Shine, Standardize, and Sustain. Each of these steps plays a crucial role in creating and maintaining an efficient workspace.

The first step, Sort, is to remove everything unnecessary from the workspace. This includes items that are broken, outdated, or no longer needed. For this, it was determined which tools or materials that are used daily and that must be at a minimum distance within the workplace, the materials that are used once a week and are within the area but not necessarily in the workplace. and the items that are handled once a month or less and are stored in the warehouse for raw materials and tools located in another area of the company.

The second step, Tidy Up, is to organize the workspace so that everything has a designated place. This makes it easy to find items when you need them and reduces time locating them in specific slots based on first-pass policy compliance.

Third step, Shine involves cleaning the workspace to ensure it is free of dirt, debris, and other contaminants. This helps keep the work area safe and healthy. Standardizing involves creating standard operating procedures for all processes and ensuring that everyone follows them. This helps reduce errors and ensures that everyone is working towards the same goal. Specific bins were located for each waste that comes out of the operations as well as weekly, monthly and daily cleaning sessions to maintain the jobs as stipulated in the previous steps in an orderly and clean manner.

Finally, Sustain implies creating a culture of continuous improvement. It seeks to encourage employees to identify areas for improvement and implement measures to address them. This helps ensure that the workspace remains efficient and productive in the long term. For the success of this implementation and in order for it to be preserved and improved over time, incentives were created for the areas that comply with the implementation and maintenance of the 5s.

Single Minute Exchange of Die (SMED) is a technique used to reduce changeover time and increase efficiency in production processes. It involves breaking down the change process into individual steps and identifying ways to simplify them. The goal is to reduce the time required for each step, as well as the total changeover time.

SMED is particularly useful in production processes that involve frequent changes, such as those in the pharmaceutical and automotive industries. By reducing changeover time, organizations can increase the number of production cycles, which reduces downtime and increases efficiency.

SMED requires two types of changes: internal and external. Internal changes involve tasks that can only be done when the computer is stopped, such as removing and replacing parts. External changes involve tasks that can be performed while the equipment is running, such as setting up tools and materials.

There were identified two moments in which the change of materials or tools involved affected the production process in the different areas and the activities to be carried out. Also the downtime generated was timed and thus the need for changes began to decrease. This means that, from the weekly or daily production scheduling, a work plan was generated and prioritized by types of fabric production for CHEILA CYC in order not to generate changes in the machinery used and to have more daily volume.

To determine the viability of the project, a financial evaluation was carried out to know the initial investment in which the resources for the development of the project were valued. This was developed with a budget and alongside human resources being the pillar of the project. The cash flow was projected for the next 5 years.

With the above information, the VAN was used as an indicator to evaluate and determine the viability and profitability of the investment project. In the case of the project, it gives a VAN of $4,729,351 which makes it a totally viable project, generating profits for the company.

The TIR is the percentage of income or loss. In this case, there is an TIR of 20%, which is higher compared to other investment projects that the company has, for which the implementation of these projects becomes a priority for CHEILA CYC as shown in figure 3.

Figure 3. Financial evaluation

PROJECT LEAN MANUFACTORY CHEILA CYC PROJECTED CASH FLOW TO 2023						
	Investment	2023	2024	2025	2026	2027
INCOME						
INCOME		$33.600.000	$57.600.000	$81.600.000	$105.600.000	$129.600.000
(=)TOTAL INCOME		$33.600.000	$57.600.000	$81.600.000	$105.600.000	$129.600.000
EXPENSES						
GENERAL DIRECTOR FEES		$24.000.000	$24.000.000	$24.000.000	$24.000.000	$24.000.000
PLANT MANAGER FEES		$21.600.000	$21.600.000	$21.600.000	$21.600.000	$21.600.000
CONSULTING AND RESEARCH FEES		$12.000.000	$12.000.000	$12.000.000	$12.000.000	$12.000.000

WORKS PAPERS		$2.400.000	$2.400.000	$2.400.000	$2.400.000	$2.400.000
TOTAL EXPENSES		$60.000.000	$60.000.000	$60.000.000	$60.000.000	$60.000.000
TOTAL INCOME		$33.600.000	$57.600.000	$81.600.000	$105.600.000	$129.600.000
VAN ACCUMULATED		- $5.900.000	- $32.300.000	- $34.700.000	- $13.100.000	$32.500.000
UTILITY	- $5.900.000	- $32.300.000	$34.700.000	- $13.100.000	$32.500.000	$102.100.000
EXPECTED RATE OF RETURN		0,07				
VAN		**$18.534.734,32**				
TIR		15%				

Source: The authors, 2023

III. SIMULATION

To evaluate the results of this implementation, a simulation was carried out through Value Stream Mapping (VSM), which is a tool to identify waste and optimize processes. This implies creating a visual representation of the current state of a production process, including all the steps involved, from the acquisition or arrival of the different raw materials involving all the processes that for the case would be cutting, confection and packaging, evaluating the steps that add value and those who do not. This helps organizations focus on eliminating non-value-adding steps or minimizing their impact on the production process, ultimately leading to greater efficiency.

VSM is particularly useful for identifying bottlenecks in the production process, which can lead to delays, increased costs, and reduced efficiency. By identifying these bottlenecks, organizations can implement measures to eliminate them or minimize their impact. VSM is also useful for identifying areas where inventory can be reduced, thus freeing up space and reducing the cost of carrying excess inventory.

Additionally, VSM is an excellent tool for creating a future state map that describes the ideal production process. This includes all the steps involved in the process, the sequence in which they occur, and the time required for each step. This future state map provides a roadmap for organizations to follow as they work to achieve lean manufacturing.

IV. RESULTS

VSM SIMULATION

STAGE 1 - For the case study, a simulation of the current processes for CHEILA CYC is carried out, where the three main processes of cutting, making and packaging are evident, by following the steps below:

1. Identify Customers
2. Analyze the requests by month and by day of the client and locate them in the corresponding data box
3. Determine daily production and requirements
4. Determine Delivery frequency
5. Determine the sequence of processes
6. Add methods and frequencies
7. Time the activities of each process to add to the data boxes

These times generate the information needed to generate the VSM and improve it.

***- Cycle time (T/C):** The time that the product takes in each operation was taken, resulting in cutting: 93 s confection: 39 s packaging 11 s*

- Assembly or change time (T/M): The times it takes in the process of cutting, assembly and change of raw material were calculated, in clothing, the time it takes to change from one order to another or change the size in the same order, the change of product was also evaluated since this has a high impact on the setup times of the machines.

- Operators: Cut: 2, tailoring: 4 and packaging: 4

- Available working time: Time available per shift in that process in seconds. This time is the total time less breaks, meeting times, cleaning times. This item is based on the working day in Colombia which is 8 hours per shift.

- Occupancy time: Machine occupancy times were recorded vs. each shift, discounting downtime for rest or cleaning.

Takt: The calculation of the Takt time begins with the calculation of the available working time between the requirements of the customer in turn.

Time takt = Time available per shift/customer requirements per shift for the case of CHEILA CYC, these times were determined based on Colombian regulations that allow 8-hour shifts, 6 days a week and customer requirements based on data from the last 3 years and projected at 35% annual growth.
Table 2 shows the times available.

Table 2. Times available

DESCRIPTION	SYMBOL	UMD	CUT	MAKING	PACKING
NUMBER OF TURNS	NT	UND	2	1	1
WORKDAY	JL	HRS/SHIFT	8	8	8
INEFFECTIVE TIME	TI	HRS/SHIFT	1	1	1
AVAILABLE TIME	**TD**	**SEC/DAY**	**50400**	**25200**	**25200**

Source: The authors, 2023

The client's requirements are based on the purchase orders of the last year to have the real data of the number of weekly units requested by clients.

When making the diagram where there is a result of a TNVA of 2080 min and a TVA of 2 minutes. With the three main cutting processes, manufacturing and packaging by implementing the different lean manufacturing methodologies, the manufacturing and packaging processes was unified, resulting in a more efficient production, with fewer reprocesses and a reduction in material waste.

Figure 4. Initial VSM results

DESCRIPTION	SYMBOL	UMD	CUT	CONFECTION	PACKAGING
NUMBER OF TURNS	NT	UND	2	1	1
WORKDAY	JL	HRS/SHIFT	8	8	8
INEFFECTIVE TIME	TI	HRS/SHIFT	1	1	1
AVAILABLE TIME	TD	SEC/DAY	50400	25200	25200
GROSS PRODUCTION	PB	UND/SHIFT	600	200	600
NUMBER OF MACHINES	NM	UND	1	4	4
% OPERATION	TF	%	90%	80%	95%
ACTUAL PRODUCTION	PR	UND/SHIFT	540	640	2280
CYCLE TIME	TC	SEC/UND	93	39	11
% OF DEFECTS	PNC	%	5%	3%	1%
PRODUCT CHANGE TIME	TCP	MIN	20	10	10
NUMBER OF OPERATORS	NO	UND	2	4	4

DESCRIPTION	SYMBOL	VALUE	UMD
MONTHLY DEMAND	DM	10000	UND/MONTH
BUSINESS DAYS X MONTH	DH	20	DAYS /MONTH
DAILY DEMAND	DD	500	UND/DAYS

DESCRIPTION	SYMBOL	UMD	A1	DESCRIPTION	SYMBOL	UMD
INVENTARIO	INV	UND	300	**INVENTARIO**	INV	UND
LEAD TIME	LTI	DAYS	1	**LEAD TIME**	LTI	DAYS

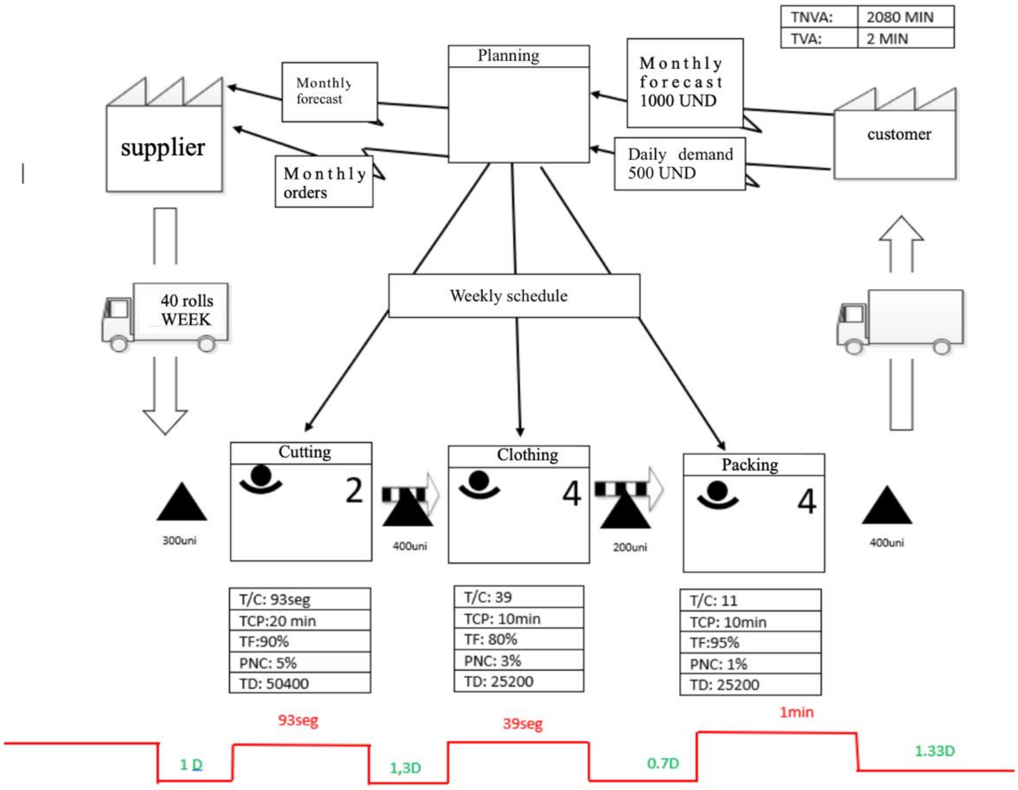
DESCRIPTION	UMD	VALUE
TVA (VALUE ADDED TIME)	MIN	2
TNVA (NO VALUE ADDED TIME)	MIN	2078,4

TIEMPO TOTAL (TT)	MIN	2081
TOUCH TIME (TOU)	%	0,0011515

DESCRIPTION	SYMBOL	UMD	VALUE
TAKT TIME	TKT	SEC/UND	100,8

Source: The authors, 2023

Figure 5. Initial VSM



Source: The authors, 2023

Figures 4 and 5 show the results of the current VSM of the company where the processes are still in place without the implementation of the selected tools and the processes are still maintained separately in cutting, clothing and packaging. Starting from the current VSM, the pertinent updates are made, resulting in the modification that is presented below.

Figure 6. Results VSM Modified

DESCRIPTION	SYMBOL	UMD	CUT	CONFECTION AND PACKAGING
NUMBER OF TURNS	NT	UND	2	1
WORKDAY	JL	HRS/SHIFT	8	8
INEFFECTIVE TIME	TI	HRS/SHIFT	1	1
AVAILABLE TIME	TD	SEC/DAY	50400	25200
GROSS PRODUCTION	PB	UND/SHIFT	600	600
NUMBER OF MACHINES	NM	UND	1	8
% OPERATION	TF	%	95%	95%
ACTUAL PRODUCTION	PR	UND/SHIFT	570	4560
CYCLE TIME	TC	SEC/UND	88	6
% OF DEFECTS	PNC	%	5%	4%
PRODUCT CHANGE TIME	TCP	MIN	10	10
NUMBER OF OPERATORS	NO	UND	2	8

DESCRIPTION	SYMBOL	VALUE	UMD
MONTHLY DEMAND	DM	10000	UND/MONTH
BUSINESS DAYS X MONTH	DH	20	DAYS/MONTH
DAILY DEMAND	DD	500	UND/DAY

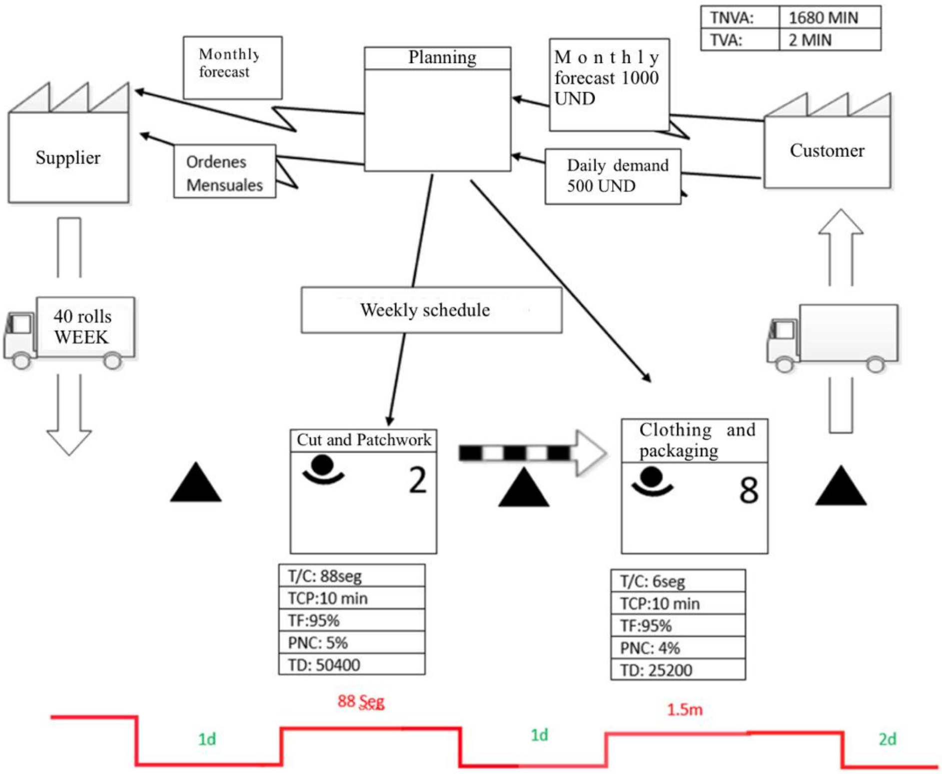
DESCRIPTION	SYMBOL	UMD	A1	A2	A3
INVENTORY	INV	UND	300	400	400
LEAD TIME	LTI	DAYS	1	1,5	1

DESCRIPTION	UMD	VALUE
TVA (VALUE ADDED TIME)	MIN	2
TNVA (NO VALUE ADDED TIME)	MIN	1680
TOTAL TIME (TT)	MIN	1682
TOUCH TIME (TOU)	%	0,00093115

DESCRIPTION	SYMBOL	UMD	VALOR
TAKT TIME	TKT	SEC/UND	100,8

Source: The authors, 2023

Figure 7. Modified VSM



Source: The authors, 2023

Figures 6 and 7 show the modifications made to the different processes and the results of the simulation, generating the changes based on the application of the tools.

V. DISCUSSION

In the clothing sector, the implementation of effective production methodologies is essential to improve productivity and efficiency in processes. Lean Manufactury, It is based on work organization methods for the improvement and optimization of the productive systems of the different companies regardless of the final product that they manage through the tools that are available, it adapts to the specific needs of production systems, fulfilling its main objective, which is cleaner production, eliminating all kinds of losses that may occur in manufacturing, improving product quality, reducing costs and reducing time.

In this sense and according to research such as "Diagnosis for the implementation of Lean Manufacturing tools, from the operations strategy in some companies of the textile clothing sector in Colombia" that was published in the magazine "Escuela de administración de negocios", reports the cases of the lean manufacturing philosophy for continuous improvement, facilitates the systemic management of organizations, formulated how to carry out the execution of lean tools and making known the relevant factors involved in the implementation of these, based on the textile sector the Valle de Aburrá in Antioquia Colombia.

This diagnosis of lean manufacturing tools, already applied and executed in different companies in the textile sector, will serve to optimize resources and serve as an example to execute the implementation process in Cheila CyC, thus the most relevant factors will be better structured.

Based on the different success stories found and the different projects already implemented in Cheila CyC, the development of the different programs for the implementation of lean manufacturing in the company was carried out, which has shown an improvement in all the processes that it impacts, generating excellent results. and greater efficiency.

VI. CONCLUSION

When carrying out the implementation of the different tools in the current production, improvements were evidenced in the different areas of the main waste found, both materials and downtime, production is cleaner and more efficient, materials are being used by 20% more and daily production has increased by 30%.

Key implementation benefits have been the ability to improve product quality by identifying and addressing defects early in the production process. This was achieved through the use of applied tools. By using these tools, the organization detected and worked on defects before they became major problems, leading to improved product quality and customer satisfaction. Additionally, by focusing on continuous improvement.

In general, the adoption of this methodology has generated significant improvements in productivity, delivery times and costs, which ultimately results in greater profitability for the organization. By reducing waste and improving efficiency, you increase production while lowering your costs, leading to higher profit margins. In addition, by optimizing product quality and customer satisfaction, competitiveness is improved, leading to higher sales and revenue.

In conclusion, this is a powerful approach to improve the efficiency, productivity and profitability of organizations. By reducing waste, improving product quality, driving continuous improvement, operational excellence and maintaining a competitive advantage. As such, it is important that organizations consider adopting lean manufacturing as a key strategy to achieve their business objectives.

At CHEILA CYC, the implementation of these programs has become the organization's continuous improvement plan, with which it is expected to further improve processes and reach an even cleaner production that is characterized by high standards of innovation and development.

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