Application of VSM to Improve a Television Productive Process of a Company in the Manaus Industrial Pole

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Abstract — Value Stream Mapping (VSM) enables, through its own symbology, the improvement of the flow of materials and information, helps to eliminate activities that do not add value and other waste. The present study refers to the application of the VSM tool for the improvement of a television productive process of a company in the Manaus Industrial Pole. The research is classified as a case study with a qualitative approach, of an applied nature with an exploratory objective. Activities throughout the production process were analyzed and characterized to obtain points of improvement in operating time, such as a 75% reduction in inventory time and 7.3% in the final line. As a contribution, it was possible to identify the points of unproductive that cause losses and failures that can help for future studies and new improvements.

Key words — Lean Manufacturing, VSM, Production Losses.

I. INTRODUCTION

New technologies move the current world, technological beginnings highly impact changes have brought on people's daily routine, and television is one of them. The television market is always in continuous enhancement so that its attractiveness does not be considered outdated. For this, the industries keep with

the competitive spirit and the goal of continuous marked improvement. The productive chain of an industry of televisions ought to be always in harmony, eliminating wastes, activities of non-value aggregated and exceeding costs so that it does not affect the final consumer.

Because of that, the thought Lean by Taiichi Ohno has become so indispensable for the harmony and consequently, adequation of the elimination of losses inside the productive chain. Adding to the productive thought the idea of lean production reducing high cost. Moreover, with it, bring tools that assist in the attainment of it among them Value Stream Mapping. According to [2], it is possible to portray through all of them the steps of the process, not only on the productive phase as in the information so that the purpose of eliminating waste is visible on the map of the current and future state.

Within this context, the main objective of this work is the application of the VSM tool on the productive process of televisions in a company from the Industrial Pole of Manaus (IPM). From the methodological point of view, this is a case study with the aim to identify possible losses over the productive chain and activities that do not aggregate any value to the final product.

II. LITERATURE REVIEW

A. Losses in the Production Process

The definition of losses is very huge and similar for many authors, considered not only as an element of rupture or something that generates losses, but also as a set of activities that do not result in bridges for the construction of the product [3].

Separately, when we deal with productive processes in any organization, there are wide sub processes connected to them that become fundamental in order to conclude all the tasks and goals. That is, in a productive process, any product to be manufactured depending on other supply networks for the creation.

The whole understanding of the losses' importance and the lost time for each piece is a key piece for the application and generation of improvements inside of a productive process, comprising the need of obtaining a continuous process. The elimination of them becomes the main goal for being absorbed of resources without any aggregated value [1].

According to [4] the current notion of losses is the result of elaborated ideas and developed circumstantially by Henry Ford and Frederick Taylor. In the vision of [5], by the fact, the natural resources being abundant in his epoch and consequently, adequate to the demands, the losses went unnoticed, although they surely existed. On The other hand [6], already visualized the losses accrued from the material stuff. However, they were not quite palpable by the simple fact of the disinformation and disastrous actions of men.

[7] and [8] in a wider way, have done the unfolding of losses through a study in the way more scathing of the same ones, classifying seven types of losses on the productive system.

The first of them is the loss by overproduction, for [7] it is crucial for all. Hereby, the other six losses are hidden and generate invisible results for the numbers of defective products. The second one is transport loss, [8] covers all the activities with movements that do not generate any value to the product and only add costs.

The third is in the processing itself, generated by the activities of processing deemed unnecessary because they do not add to the basic qualities that the product should get. According to [9] all of these can be extinguished without changing as the functional and features of the product.

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The loss by fabrication of defective products is classified as the fourth on the list. Products are manufactured. However, they don't pass through the quality requirements without a pattern of conformity. As quoted above by [10], all the rework of the product is simply the result of a loss by not attempting to follow all the quality patterns, admitting a strong influence over all the productive systems.

The embezzlement between time of the delivery of the product and the time of fabrication is denominated as another loss, from the stock. In the view of [4], the accumulation of stocks cannot be avoided if the lead-time of the product fabrication is bigger than the determined delivery period. Generating high financial costs, products are becoming obsolete, and sales are becoming not concluded.

Other losses through the use of dispensable movements of collaborators on the activities, are denominated as movement losses, that for [7] contradicts with working effectively, because not even all these losses are easy to identify or to eliminate, due to the occurrence of lack of effectively work instructions many times.

When the time intervals occur in a way not to be effectively use, whether from humans or machines, it can already be seen as another kind of loss: Waiting loss. When they become daily, the costs rocket, what should cost to the associates an assumption value, occurring twice as much as expected. Tracking the seven loss types are directly correlated with the disposal of the equipment physically on the line, quoting the excessive transport, the unnecessary accumulation of movement and the stocks [11].

Besides these operational losses, the losses by the machine's performances can also be analyzed. [12] highlights the approaches for the calculation by the OEE, grouping the losses by the performance, availability, and quality, the TPM will be responsible for grouping these and the human losses and from the administrative part.

B. Lean Manufacturing

In the companies' current reality, the way of being competitive has become a duty of all for the survival in the market. Wide market and diversified, is continuously updating whether of technological advances, governmental changes, decreasing or increasing economy for that, decisions must be taken in fast and concise ways for not obtaining the opposite effect. The Lean Manufacturing application correctly becomes one of the essential pieces for a good managerial operation of a micro enterprise or even a multinational. The concept of Lean Manufacturing is understood as a system that presents a wide diversity of tools for detection and elimination of losses and activities of non-aggregated value inside of a productive process. Creating a new production flow is capable of optimizing the processes so that the minimums of resources are used, reducing the cycle time, task time and stocktaking [13].

Developed in Japan by Taiichi Ohno this methodology has been enhanced after many studies of enhancement in the productive processes in a continent already used with its techniques, resulting in the addition from Japanese to American technology. The manufacturing becomes lean, making a necessary product, on the right time and right quantity, eliminating the losses during fabrication and reducing the abundant costs [14].

The losses identified over the processes, and its respective enhancements can be developed and studied by this lean system of production by the means of many techniques such as the Kaizen, Six Sigma, and the Value Stream Mapping [8].

C. Value Stream Mapping

The Value Stream Mapping (VSM) is a tool of huge importance to a system of lean production. From it, any organization is capable of visualizing all the value streams of one or more productive processes. This tool influences directly on the possible enhancements, decision-making and the effective performance of any business indicator. The roamed paths by the product since the provider until the final consumer start to be analyzed along the activities that aggregates value or not [15].

Value Stream Mapping is a tool from the lean manufacturing that has brought a better information for many industrial sectors and has been ascending positively with the important support to involved areas because besides dealing with strategic ways the stabilization of directions to be taken, opens the possibility to the visualization as an appropriate design [16].

According to [17] we consider value streams any event that aggregates value or not that is essential for the production of a product. The stream completes itself by the route done from the raw material to the final consumer, completing all the knowledge gained by Lean Manufacturing, in the need of continuous enhancements in individual activities or in a global context.

The VSM or MFV results in the visual application of process's streams, materials, and information. Thereby, sketch in a simple way the functioning of a value chain and predictions for future enhancements. Identifying all the steps of a process, the losses over the activities, lead times, the way that the stream value will be done, the performance measures so as the opportunities of process improvement.

The technique to map the process by its value stream needs symbols and icons previously patterned that together will determine which is the current state and the future one. These are divided into categories that are going to represent the material's stream, information stream, and generalized icons. The following Fig. 1 shows some of these symbols and icons.

Fig. 1. Symbolology VSM.

The lead times of a value stream in a productive chain can be understood as the time spent within a system so that the transformation of the raw material into the final product

occurs. The identification of it occurs when visualizing the waiting time of processing, inspection, and transport [14]

III. METHODOLOGY

A. Research Goal

In this section, the methodological procedures will be detailed used over this work as the identification of the characterization of the research and which steps taken so that we finally develop the final data.

The current work has used tools of lean manufacturing, in evidence to the application of e VSM (Value Stream Mapping) for identifying the losses and the activities that do not aggregate any value to the fabrication processes of televisions.

The research considering the technical procedure has resulted in a case study aiming to the Value Stream Mapping, which belongs to the productive process of an industry of electronic products from the industrial pole of Manaus.

According to [18], the case study is a methodology extremely useful to new knowledge and new concepts, as which procedures are used to its applicability and, which are used in a practical way. According to the methodology VSM, the case study can be taken accordingly Fig. 2.

Fig. 2. Methodological procedure.

B. Research Strategy

As the first step to the beginning of this study, we characterized the literature revision according to the needed attributes for the analysis of a productive system, stock management and all the chain inserted, started in October 2020 until January 2021. Using the brainstorming methodology, it has been analyzed the functioning of the productive televisions' chains and the definition of each step, since the reception of the compounds by international providers until the expedition finished product in the final line.

C. Sample and Data Collection

As of the utilized methodology by the tool VSM, the phases could be done:

1. Product's identification to be analyzed: After the evaluation of the productive process, it was possible to identify in an effective way which products and which processes would be part of the study. The production plan was essential for the model's choice to be part of the research.

2. Creation of the Current State Map: With the camp's visit, the processes so as the main activities connected to them were identified, from the main suppliers needed in the

beginning of the chain until the assembly process and the final packing. Summing up time, resources, and activities altogether, which did not aggregate any value.

3. Current State evaluation and analysis: Identification of the activities that aggregate value and the ones that do not aggregate value, such as the losses during the stream, also as the excessive stocktaking number and wait time between the activities from the final line.

4. Future's State Creation: Meeting with the involved once in the elaboration of the project, resulting in the future's state projection with the possible improvements to the elimination of time excess, stocktaking, labor.

5. Action plan elaboration: With the lean methodology assistance, the creation of an action plan that interconnects the current state of the future in a clear and easier way of interpretation and resolution.

6. Result's analysis: Improvement's analysis of the future proposals and predictions.

D. Data Analysis

After evaluating the current state and designing, improvement actions were recommended in order to achieve the future state. Such actions consisted of adjustment activities in the production process, machine performance and physical arrangement of the process.

IV. FINDINGS AND DISCUSSIONS

In this section will be presented the application of the tool VSM in order to recognize the losses over the productive chain and eliminate them afterwards. Thus, identifying the possible losses over the processes evaluated since the PCP. It is important to understand that a television's production involves receiving some materials like speakers, back covers and in this case, PCBA signs from international suppliers.

A. Television's Productive Process Flowchart

Before starting the television's, productive process mapping it is necessary to understand which the steps are involved in the final product result. Depending on the television model, the material composed can vary from manufacturers, such as UHD, OLED, USHD, FHD and NANO. The differences can be found in the screen thickness, on the picture quality, on the inch size, on the sound from the intern and external accessories from it. Because of this, the production's control and planning must specify correctly the models to be manufactured, because back covers, accessories like speakers and Wi-Fi and PCB's are supplied by other partners.

In the subsequent flowchart, Fig. 3 below, it's possible to see the national and international material receipt and, visibly, the discrepancy between the processes. Between the back covers and accessory's arrival, the PCB's group a bigger number of steps and, for this reason, a bigger number of losses. As an initial decision, it has been chosen as the step PCBA until the final line, where it is noticeable in the improvement's application.

Fig. 3. TV's Productive Process Flowchart.

B. Television's Productive Process Mapping

The televisions' productive process concerns some steps that can be detailed hereinafter with the VSM tool support:

- PCP: Planning and production control is responsible for receiving the necessary demand daily in conjunction with what is needed for all the steps of the productive chain. It determined the daily production plan and monthly consequently.

- China/Korea: After the demand receiving by the PCP, the suppliers are activated to the signs and accessories sending so that the production can be completed and attended.

- Doka: The needed material's receiving that came from the supplier are assigned on docks that instantly are going to be analyzed by IQC, responsible by the quality control of the received products.

- TV Storage Factory 5: In the subsequent process, after the dock, the products are, in this case the PCBs signs.

- Inventory I: After storing on the factory 5 storage, the received signs go through the first stocktaking that floodgates 10.000 pieces in 7,85 hours, common time of the work shift.

- Inventory II: Following the first stocktaking, the signs are directed to a second stocktaking with the same time and for the same time, 10.000 pieces in 7,85 hours. The main losses found between those 2 stocktaking is the excess of process and time between the factory 5 and the factory SMT.

- Storage SMT: Before the signs go through the SMT process, they keep stocked during a period of 15,7 hours with a set of 20.000 pieces, where they go through the division and distribution process (Kitting).

- Inventory III: Setting off from the storage, they are scheduled for the third time within 3 hours with a set of 5.000 pieces. As a kind of loss, this was the stocktaking process right after the SMT storage.

- SMT process: After stocktaking, the PCB signs, go through the SMT process, where all the necessary compounds for the future functioning of a TV can be assembled, involving inserter machines, weld paste application and fusion in order that the final process result must be fully agreeable with the demanded parameters by the company.

Within this process, it is possible to obtain a time cycle of 25 minutes, with the production of 5.000 PCB signs in 3 hours.

- Inventory IV: Roughly, 1000 pieces are scheduled each 10 minutes.

- Inventory V: Dealing with an extensive industrial field, the preparation factories of compounds keep divided with each other. For the movement of processed pieces until the final line, cars are necessary, elevators that help interconnecting. With the elevator's use within 1 hour, 1.000 pieces are scheduled.

- Inventory VI: The distribution occurs with it's due to recommendations for the sixth stocktaking that receives within 3 hours, 5.000 signs.

- PCBA storage: Once they have arrived from the stocktaking, all the signs are scheduled in a PCBA storage at the factory 1, responsible for the television' s production. Within 23,55 hours, 30.000 PCB signs are received, organized by TV' s inch and model type required.

- Inventory VII: 7,85 hours 10.000 pieces are scheduled.

- Inventory VIII: Each hour, 1.500 signs are scheduled before arriving at the final line.

- Inventory IX: As the last stocktaking, the signs are directed to the final line with the necessary specifications, within one hour 500 PCB signs are distributed.

- Final Line A04: The fourth factory's assembly line occupies 23,6% of the whole television' s production plan. Within a cycle time of 5,83 minutes, with a total of 60 workplaces. To these final assembly processes, it has been analyzed a production bottleneck of 8,34 seconds who influences directly on cycle time and the activities that aggregate value to the product. Furthermore, identifying the high movement when handling the work instrument and unnecessary displacements in the positions.

On the Table I following, it's possible to visualize the time of each process that are going to be on the Current State Map on the Fig. 4.

TABLE I: VSM CURRENT STATE - LEAD TIME 228,96 HOURS - PROCESS
TIME 30,8 MINUTES – PHASES AND TIMES OF THE PROCESS

In-Process Activity	Crossing Time	Activity Time
PCP - Production	30 days	7,85 hours
Storage TV Fab 5	20 days	157 hours
Inventory I	1 day	7,85 hours
Inventory II	1 day	7,85 hours
Storage SMT	2 days	15,7 hours
Inventory III	1 day	3 hours
SMT Process	1 day	25 minutes
Inventory IV	1 day	10 minutes
Inventory V	1 day	1 hour
Inventory VI	1 day	3 hours
Storage PCBA	1 day	23,55 hours
Inventory VII	1 day	7,85 hours
Inventory VIII	1 day	1 hour
Inventory IX	1 day	1 hour
Final Assembly A04	1 day	5,8 minutes

C. Implementation Proposal

With current state mapping concluded, it has been possible to analyze the production bottlenecks of the final line and the losses spots over the productive chain involving the PCBA signs distribution. The under warehousing over the PCBA signs productive process until the final line must be eliminated, so this way the whole production time must be reduced. Furthermore, the stocktaking capacity found is beyond what it is required, occupying important areas desired to other activities. As an example, an awaited area to the Setup realization of the storage PCBA.

On the final line, some spots have been found that act directly on the production line efficiency and on activities backlog that do not aggregate value to the product. As a result, it has been proposed some improvements to the storage excess elimination, losses in the final line and consequently the costs reduction, according to Table II.

Fig. 4. VSM – Current State: TV's Productive Process Flowchart.

TABLE II: ACTION PLAN

Process	Problem	Losses	Problem Description	Proposal for Improvement	Proposal Status	Deadline	Cost	Gain
Inventory	Excess of material	Storage	Large quantity of material allocated in sub-stock along the PCBA productive process	Change and review of real demand required by Final Assembly	Applied	Short / Medium Term	R\$0,00	Savings in Operation Time
	Excess of transportation	Transport/Movement	Long distance between Factory 1 and Factory 2	Change in the Transport Flow of PCBA boards	Improvement Suggestion	Long Term	R\$10 K	Reduction of Operation Time
Storage PCBA	Lack of Area for Setup	Waiting/Movement	Inefficient Setup, Available area not enough	PCBA Warehouse Optimization and Standardization	In Development	Long Term	R\$1 K	Quality and Time Gain
	Excess storage	Storage	Stock area available for 67,000 boards but in use only for 30,000 boards	Process Optimization and area Relocation to other Processes	Applied	Short / Medium Term	R\$0,00	Area Gain and Efficiency
Final Assembly	PCBA board input	Waiting/Movement	Difficulty when inserting the PCBA Boxes in the Line Support	INSERT TRACK TO CHANGE BOX DISPOSAL	Applied	Short / Medium Term	R\$0,00	Takt Time Reduction from 7.31 s to 5.51 s
	Disposal difficulty	Movement / Waiting	Support of Speaker Boxes misplaced generating difficulty in Disposal	Support Relocation	Applied	Short / Medium Term	R\$0,00	Takt Time Reduction from 7 s to 5.13 s
	Difficulty of	Movement	Difficulty in	Installation of an	Improvement	Long	R\$10 K	Labor Reduction

application of adhesive sheet	/ Waiting	Application and Disposal of Adhesive Sheet on Television	Automatic Machine (Insulator)	Suggestion	Term		From 1 to 0
Difficulty in the module input	Movement / Waiting	Difficulty in opening Module Bag (03 adhesive tapes)	Reduce Quantity of tapes in the Module Bag	Improvement Suggestion	Long Term	R\$10 K	Takt Time Reduction from 6.7 s to 5.2 s
Disorder in the packaging station	Movement / Waiting	Difficulty in separating EPS from Television Models	Supplier send separate EPS by type of model	In Development	Short / Medium Term	R\$1 K	Takt Time Reduction from 8.3 s to 6.5 s and Labor Reduction From 5 to 3
Back cover pressure difficulty	Movement / Waiting	Displacement to press Back Cover manually	Installing Auto Back Cover Press	In Development	Short / Medium Term	R\$1 K	Takt Time Reduction from 4.7 s to 3.1 and Labor Reduction From 1 to 0
Loose screw inside the module	Movement / Waiting / Rework	Automatic Screwdriver disposing screw inside the Module	Installing a Machine Screw Holder	Applied	Short / Medium Term	R\$0,00	Takt Time Reduction from 6.2 s to 5.3 s

Thereby, the future states activities time are found on the Table III could be defined according to the improvement's proposal. Consequently, on the Fig. 5 it is possible to analyze the future state by the map, visibly below.

TABLE III: VSM FUTURE STATE - LEAD TIME 206,21 HOURS - PROCESS TIME 30,3 MINUTES – PHASES AND TIMES OF THE PROCESS REVIEWED

In-Process Activity	Crossing Time	Activity Time
PCP - Production	30 days	7,85 hours
Storage TV Fab 5	20 days	157 hours
Inventory I	1 day	7,85 hours
Storage SMT	2 days	15,7 hours
SMT Process	1 day	25 minutes
Inventory II	1 day	10 minutes
Storage PCBA	1 day	23,55 hours
Inventory III	1 day	1 hour
Final Assembly A04	1 day	5,3 minutes

Fig. 5. VSM – Future State: TV's Productive Process Flowchart.

V. CONCLUSION

The application of the VSM tool is essential for the whole analysis in a productive system. Besides enabling whole camp's visualization, strategically guarantees the signalization of what is loss and does not aggregate any value to the final product. In addition, in the current study, the tool has been sharp on the characterization of all processes that involve television production, with the time identification of each occupational operation and parameters.

The current state mapping guaranteed the lead-time time's summarization and from the operational time of each activity. Guaranteeing the bigger loss spots and production bottlenecks per wait during the stream until the final line. The set of all this, ended up on an action plan to the activity's improvement with aggregate value and storage limitation, before disordered and excessive.

Eliminating excessive stocktaking during the processing to storages and posts with a high index of time wait and movement with non-aggregated value, reducing the stocktaking time by 75% and on the final line by 7,3%.

Besides that, the final line efficiency through the application of all the improvements will enhance substantially along with the reduction from 29 to 26 people.

As recommendations for the continuity to the study, it is suggested enhancement of the under processes over the productive chain with the factories involved, in order to it, the demand must be under perfect adequation with all the areas and productive processes. It is also suggested the implementation of bigger automations in the final line, eliminating residual activities and excessive wait time.

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