Processes Improvement at the Science4you Factory

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Abstract

The competition in the economy is growing, the customers are rigorous and the competition is strong. The companies need to improve its processes. It is almost mandatory to produce faster, with better quality for the best cost.

Science4you is a Portuguese company that produces toys. The company needs to raise the efficiency of its processes, to create more value for the client. It is vital to produce the product that client need, when he need and with a price that he is willing to pay. The objective of this Dissertation is to create a plan of continuous improvement to make the productive process more efficient and flexible.

The improvement plan is based in the Lean culture and integrates various methodologies and tools to seize the maximum potential of the Culture.

The implementation of the improvement plan allows the production teams to make the process more efficient and flexible, increasing the workers satisfaction and decreasing the production times and costs. It makes possible to produce more quantity with less cost, maintaining the team´s happiness and productiveness. The implementation allows Science4you to increase the value for the client and the profit because of the costs reduction and the increase of the production potential.

It is important to refer the cohesion and robustness of the various Lean methodologies and tools working together. This holistic perspective about the Lean Culture allow the extending and increasing of the positive impacts of the plan in long-term.

Key Words: Lean Culture, Toys Industry, Productive Process, Efficiency, and Flexibility.

Abbreviations: JIT – Just-in-Time; PL – Production Leveling; SMED – Single Minute Exchange of Die; STD – Standardization; VM – Visual Management; VSM – Value Stream Mapping.

1. Introduction

The industry is in constant development and changing, nowadays the mass production is being gradually transformed into Lean production. The customers are more and more rigorous and the competitors more prepared, so it is mandatory to be more efficient, producing more, with less.

To clarify the first paragraph is important to characterize two production strategies, Push – Make to Stock and Pull – Make to Order. The first one is focused in the production and can be summarize by the mass production of big batches (Womack et al., 1990). The second is focused in the clients and can be summarize in production driven by demand. The Pull strategy is intimal related with Lean culture and is getting a lot of support by industrial companies (Womack et al., 1990).

Lean culture represents a solution for the lack of efficiency and flexibility of the industrial processes. It has three methodologies that express well the Lean concept: 1) Kaizen, representing the continuous improvement, the search for the perfection, 2) Just-in-Time, characterized by the reactive production driven by the costumer's demand and 3) Jidoka representing the anticipation and the automatic repair of errors. Those methodologies allow the companies to reduce the wastes and to improve the quality of the allocation of resources.

Science4you context clearly fits in that scenario, with rigorous clients and competitors. Besides that, the growth in sales is much higher than the

growth in capacity. Because of this, it is mandatory to produce more, consuming less resources.

The objective of the Dissertation is the creation of a continuous improvement plan that allow the working teams to increase the efficiency and the flexibility of the production process.

2. Case Study

2.1. Science4you and the Market

Science4you is a Portuguese company that develop, produce and sells educative toys. The toys industry is a competitive and in growing industry that moves thousands of millions of euros every year. The figure 1 shows it itself:

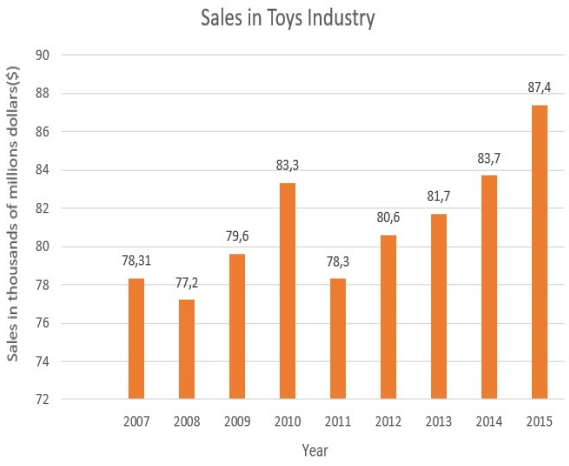

Figure 1 - Annual Sales of Toys Industry

In Science4you, five hundred different toys are sold and produced with the propose of educate the kids in a funny way. The idea of connecting education with toys is present in the mission of the company: “Increase the level of education of society by the development of toys and games that allow kids to learn while they play”.

The table 1 shows the evolution of Science4you’s sales volume over the last years:

Table 1 - Annual Sales and Growth of Science4you

Year	Sales (M€)	Growth (%)
2014	6	N/A
2015	11	83
2016	16	45

It is possible to verify the fast growth of the company. It is expected that in 2017 the sales volume will growth again.

The company is the only producer of toys in Portugal, and the third biggest producer in Iberian Peninsula. The biggest competitors in the Portuguese educative toys market are: Clementoni, 4M, Imaginarium and EducaBorras. It is also important to refer Hasbro, Lego and Mattel that are not inserted in the education toys market, but have a big market quote in Portuguese toys market.

The success of Science4you can be explained by the innovative concept of the products: the educative toy that allows the kids to have fun while they learn. Besides that, the product is very diverse and cover all the knowledge areas. That makes possible to satisfy the need of all type of young customer. It is important to refer a critical point that helped to build the success, the values of the company: excellence, effort, and efficiency. Those are clearly reflected in the daily work in the plant.

2.2. Product

Science4you produce diverse types of educational toys. In this Dissertation, the focus in in the production of kits. Kits are composed by:

- Cardboard box;
- Instructions manual;
- Liquid reagents;
- Solid reagents;
- Non-reagent solids.

The figure 2 shows examples of kit’s contents:

Figure 2- Example of kit’s contents

2.3. Production Process

The raw material is brought from suppliers and are transformed into final product in the Science4you's plant located in MARL, Lisbon. The process of production is divided in five parts: dyes production, liquids filling, primary production, intermediate production, and final production.

The figure 3 shows the Value Stream Mapping of the production process:

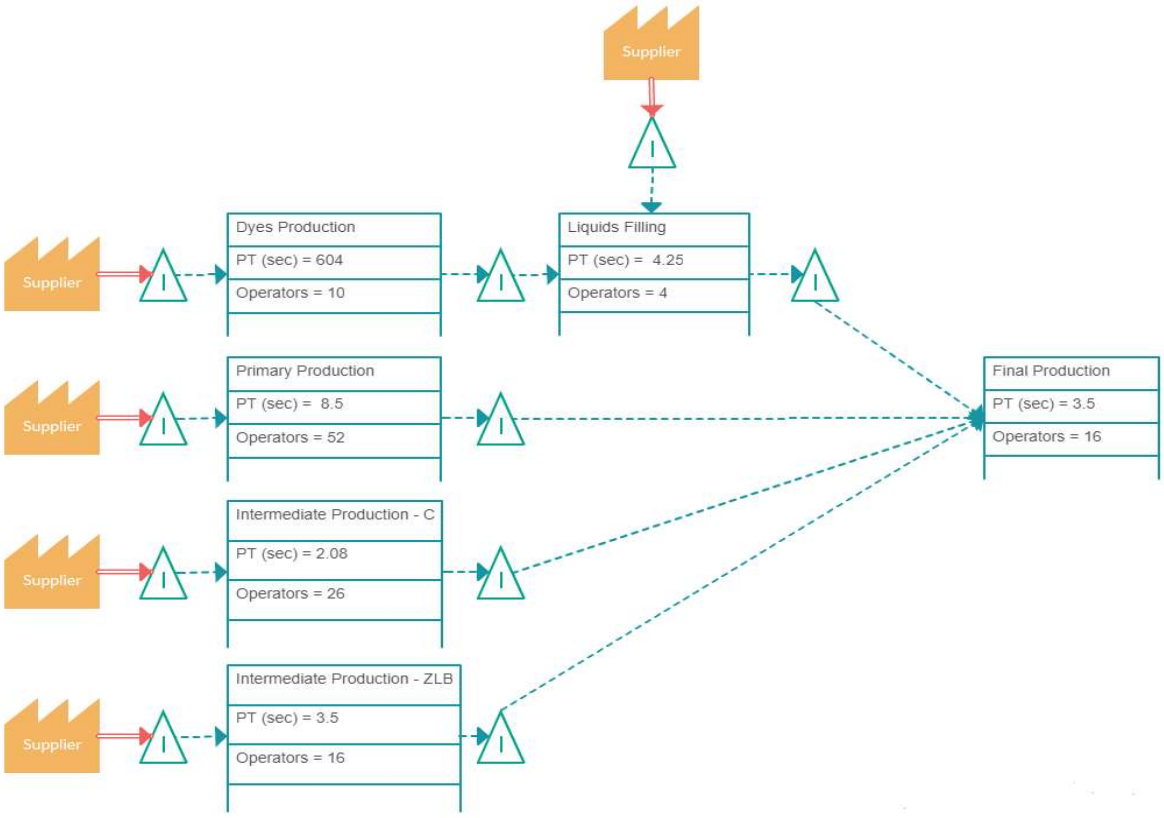

Figure 3 - VSM of the Production Process

Detailing the various parts of the process:

- Dyes production → phase where alimentary dyes are produced. The alimentary dyes are the only type of dyes produced in the plant, the others are brought from vendors;

- Liquids filing → phase where the liquids are placed in small bottles and labelled. All of them, except alimentary dyes are brought from vendors;

The figure 4 shows an example of bottle:

Figure 4 - Example of bottles

- Primary production → phase where the solid reagents are placed in small bottles and bags, labelled, and grouped in packs, depending on the demand;
- Intermediate production → the non-reagent solid materials (brought from vendors) are placed in cuvettes and zip lock bags, labelled and packed;
- Final production → all the components of the kit are grouped together in the final box, labelled, packed, and prepared for storage or expedition.

It is important to note that a kit does not exactly need to pass through the five parts of the process. This fact increases even more the variability to the process, making the case study even more challenging.

2.4. Problem to solve

In the Dissertation, the focus is in the kits that need all the phases of the process to be built, because it represents a considerable part of the sales and allow the creation of a better solution, integrating all the phases of the production process.

At the begin of a complete process it starts with three phases at the same time: dyes production, primary production, and intermediate production (covets and zip lock production). After the dyes production is completed it is time

to start the liquid filing process, and after all the phases are complete, final production starts.

3. Literature Review

3.1. Overview

The objective of this work is to improve an industrial production process. The lean Cultures fits perfectly in the needs (Hines et al., 2004) and is used to achieve the goal.

3.2. Lean Thinking

First is important to define the Lean Thinking, the base of every good Lean Implementation. There are two milestones in the definition of Lean Thinking: I) Womack & Jones (1996) and II) Marchwinski et al., 2008.

I. Lean Thinking is defined as a process with five steps:
   1. Identification of specific value for the client (by product);
   2. Analyze of value chain with focus in the elimination of waste;
   3. Creation of a process that allows an efficient flow of goods from the raw material to the final product;
   4. Implementation of a Pull system, where the demand delimits the production;
   5. Application of continuous improvement, trying to achieve the perfection.

II. Lean Thinking is defined using three concepts:
   1. Purpose → The main purpose of a company should be to fit in the client's needs. To achieve that it is mandatory to understand what is valued by the clients;
   2. Process → The process must have in consideration the purpose and to be: valuable by the client, capable to produce a good result, available when its needed, suitable (maintaining a continuous flow) and flexible. Besides that, the process must respect: flow, pull strategy and leveling of the activities;
   3. People → The involvement of every intervenient in the process is very important. It allows the company to create a better value chain, shorting the distance between the company and the client. To achieve an appropriate level of involvement is necessary to: create a strategy, elaborate frequent studies to continuous improve the processes and create standards of work and management.

3.3. Lean Methodologies and Tools

With the most conceptual and theoretical part of Lean Culture presented, is necessary to show the practical side of Lean. There are three methodologies and nine tools with relevance for this paper. The methodologies are: 1) Kaizen, 2) Just-in_Time and 3) Jidoka. The tools are: I) Value Stream Mapping, II) Standardization, III) Kanban, IV) FiveS, V) Visual Management, VI) Leveling, VII) Single Minute Exchange of die, VIII) Five Whys and IX) Poka-Yoke.

1. Kaizen → Represents the continuous improvement (Bessant et al., 2001);
2. Just-in-Time → Represents the production just when it is needed and in the quantity needed Marchwinski et al., 2008);
3. Jidoka → represents the automation of processes (Dennis, 2002);

I. Value Stream Mapping → it is a diagram that represents the flow of the product (and its information) through the set of processes in the value chain (Rother & Shook, 1999);

II. Standardization → It is a structural tool based in the production of standards to well-define tasks and processes (Dennis, 2002);

III. Kanban → It is a visual tool used to implement the Just-in-Time production. Usually is represented by a rectangular cardboard and have the function to authorize the picking or production of products. The cardboards contain information about the products, for example: vendor, client, storage location and transportation method (Dennis, 2002);

IV. FiveS → five actions represent It: 1) sort, 2) set in order, 3) shine, 4) standardize and 5) sustain. 1) Separate what create value from what create waste; 2) Classify what was separated by the frequency it is used; 3) Clean and organize the workplace; 4) Maintain the cleanness and organization overtime, standardizing its processes; 5) Involve all the people in the processes contributing to improve overtime (Gapp et al., 2008);

V. Visual Management → This tool can be described by the exposal of the relevant information for all the people involved in the process. This information must be simple, suggestive and can be, for examples: about tools, explaining of tasks, performance indicators. (Marchwinski et al., 2008);

VI. Leveling → This tool is related with leveling of tasks. Patterns of production are created to fulfill the demand. The quantities of productions patterns are defined by the needs of the clients. Usually it is used to efficiently respond to a very variable demand and to a high quantity of different products to produce (Marchwinki et al., 2008);

VII. Single Minute Exchange of Die → This tool uses a set of tasks that should be done to decrease the setup times (Mileham et al. (1999);

VIII. Five Whys → This tool work as a set of five similar iterations. A problem is found and, asking why, the cause is found. The why is asked again and the cause of the cause found in first place is found. Five iterations are needed (sometimes less than five) to reach the root cause (Melton, 2005);

IX. Poka-Yoke → This means mistake prevention. Simple and cheap devices are used to prevent and detect errors, solving them, avoiding stops in the production system (Dennis, 2002).

The figure 5 shows the literature read and the methodologies and tools addressed:

Year	Authors	Kaizen	JIT	Jidoka	VSM	STD	Kanban	5S	VM	PL	SMED	Five Whys	Poka-Yoke
1988	Ohno	X	X	X		X	X						X
1998	Baykoç et al.		X				X						
1999	Mileham et al.										X		
2001	Bessant et al.	X											
2001	Brunet et al.	X											
2003	Fullerton et al.		X				X						
2003	Rother et al.	X			X								
2005	Melton	X			X		X	X				X	
2006	Parry et al.								X				
2006	Bateman et al.	X											
2007	Michalska et al.							X					
2007	Sutherland et al.	X										X	
2008	Gapp et al.	X						X					
2009	Hüttmeir et al.									X			
2010	Bayo et al.							X					
2010	Rahman et al.							X					
2012	Rahani et al.				X								
2012	Naufal et al.		X				X						
2013	Costa et al.					X		X	X		X		
2013	Rahman et al.						X						
2014	Brox et al.		X										
2015	Mech et al.			X									X

Figure 5 - Part of the literature read and the methodologies and tools addressed

3.4. Lean Implementation

To find the best implementation method, diverse literature was read.

Analyzing the literature and taking in consideration:

- Bhasin & Burcher (2005) said that the failure of a lot of lean implementation is because less than five tools are used;
- Sundar et al. (2014) emphasize the importance of the integration and simultaneous application of diverse lean methodologies and tools.

Following that, an adapted methodology of Lean implementation that integrate various methodologies and tools is built.

The methodology used in the Dissertation is an adaptation based in the Melton perspective of Lean Thinking. Melton describe the Lean Thinking in five steps: 1) data collection, 2) data analyses; 3) improvement proposal, 4) implementation of the proposal and 5) control of results.

The figure 6 shows a scheme of the methodology used:

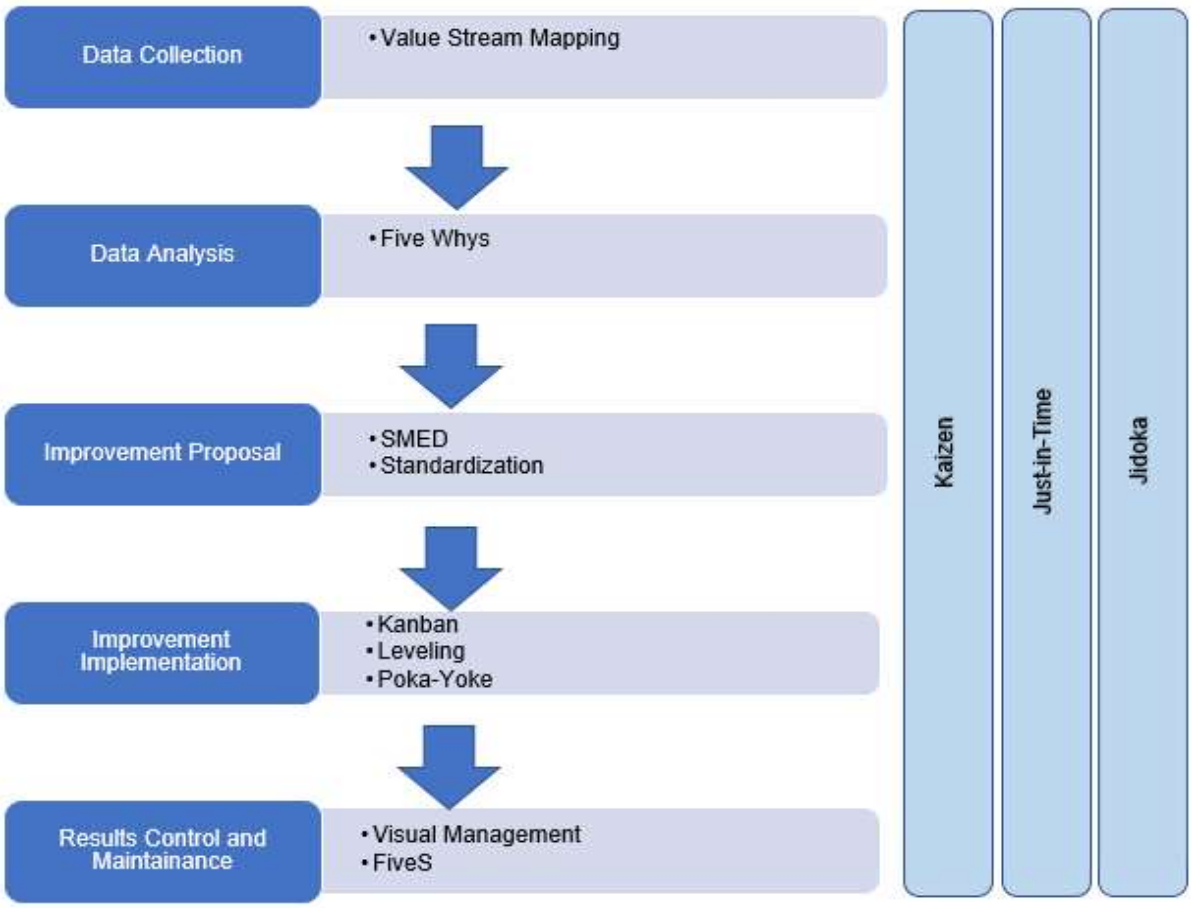

Figure 6 - Lean Implementation Methodology

The 1) collection of data starts with the exhaustive search of data about the processes running in the value chain. This data can be used to build a Value Stream Mapping and find the wastes in the tasks. In the 2) data analysis, the tasks that produce wastes are analyzed and the root cause of the wastes can be found by using the Five Whys tool. In the 3) improvement proposal, an improvement plan is created using two tools: standardization to increase the efficiency of the process and helps to maintain the improvement mentality; and SMED, to reduce the setup times of operations. Once the improvement plan is built it necessary to 4) implement it. Tools as Kanban, Leveling and Poka-Yoke are very important to an effective implantation of the plan. For the last, but not less important, 5) the controlling of the results, always with the focus in the continuous improvement. It is not just about maintain what was done, but to improve even more, searching for the perfection. To achieve this, tools as Visual Management and FiveS are very effective and helps to reach very successful results.

4. Solution Proposal

The solution is based in the Lean culture, and have the objective of increase the efficiency and flexibility in the industrial production process. The solution is based in three Lean methodologies: Kaizen, Just-in-Time and Jidoka; and nine Lean tools: Value Stream Mapping, Standardization, Kankan, Leveling, FiveS, Visual Management, Single Minute Exchange to Die, Five Whys and Poka-Yoke. The various methodologies and tools are used to create an integrated solution that can use the advantages of each one and mitigate the disadvantages.

The solution found is not a simply group of proposals, but an integrated group where every proposal is related with each other, building a strong and robust solution. The solution will improve the system in short-term, but the main point is the potential of improvement in long-term. The FiveS tool can be used regularly to complement the implementation solution and allow the continuous improvement in long-term.

There are seven proposals, two of them more general, with more focus in the long term, and the remaining five, more specific.

The individual proposals (starting by the two general ones) are:

4.1. Involvement of the team

Involvement of all the stakeholders in the process → it allows better improvements and helps the solution to remain in long term. This is not just going to increase the efficiency of the processes, but increase too, the satisfaction of the workers and their productivity contributing to the increase of the total welfare;

4.2. Standardization and Visual Management

Application of standardization and visual management to the entire production process → it allows all the involved to understand the process and even help to produce standards for the process (how better to make standards than the workers that do the task daily?). This will increase the satisfaction of the workers and the understanding of the process. With motivated and well-prepared workers, the productivity raise, the handling costs and times are reduced and the total efficiency highly increase. It will allow improvement in short-term, but not just it, the improvement in long-term will persist and get an even higher degree;

4.3. Kanban Implementation

Application of Kanban in primary production, intermediate production, and final production → it increases the flexibility of the system and decrease the processing and setup time. The advantages of this implementation are not only related with this itself, because kanban is needed in other situation that are contemplate in the next chapters of this paper.

4.4. Work in Process and Inventory of Raw Material

There are a lot of Work in Progress and Inventory of Raw Material near the primary production, intermediate production and final production. It creates disorganization, difficulties to move fluently and highly increase the setup times because it is hard for the works to get the batch needed. To solve this situation two tools are used: visual management and kanban. Those tools will be used to:

1. Identify and to delimit the areas where the stocks of raw material and product in progress should be placed. It will make the stocks zone more organized, easier to handle and allow a better circulation of people in the area;
2. Divide the areas in five parts to allow the division of the different batches stored. It makes possible to have a more organized stock, increasing the flexibility of the process and decreasing the setup times, because it will be easier for the workers to store and pick the products;
3. Implement Kanban to increase the control over the processes. It allows the team to better understand the process and to better manage and organize the flow and storage of stocks of raw material and product in progress.

4.5. Batch Size

This point is not directly related with Lean, because Just-in-Time methodology always support the reducing of the batches size.

In this case is defined a minimum size for batches in three phases of the production: labelling of bottles, labelling of bags and the covet's line in the intermediate production. This is done because at a specific batch size the processing time is minimized. It is feasible in a Lean perspective because the batch size that minimize the time per unit is much lower than usual size of the batch produced. In this case is a win-win situation. It decreases the unitary processing time, reducing the handling cost (that are time related) or allow the production team, to produce more, for the same cost.

The table 2 quantify the advantages of this proposal:

Table 2 - Advantages of Lot Size Optimization

Processing time (sec)				
Non-Optimized Batches		Optimized Batches		
Seconds	Minutes	Seconds	Minutes	
0,6	0,01	0,5	0,00833333	Labelling of bottles and bags
2,4	0,04	1,58	0,02633333	Intermediate production - covets
Annual Capacity of Production				
Non-Optimized Batches		Optimized Batches		**Difference**
12672000		15206400		**2'534'400**
3168000		4812151,9		**1'644'152**
Daily Work (h)			8	
Minutes of work per year			126720	

Emphasized with blue are the increase in the annual capacity to produce units of bags and bottles (so the result for the two labelling activities, bottles, and bags, is 5'068'000 of annual capacity of production increasing). Emphasized with orange is the increase in the annual capacity to produce units.

4.6. Alimentary dyes production

The alimentary dyes production processing time represents 98.7% of the total processing time of the system. Because of that it is mandatory to do something about it. The high processing time is directly related with the chemistry nature of it, so it is not feasible to reduce. The proposal is to always ensure the begin and the finishing of the production exactly when it is available and needed to be done. To do this, specific rotative employs should be assign to this task (when it is not needed to produce dyes, they should be doing tasks that can be stopped anytime) and run the process when it is needed and available. To warn the employs that the processing need to be done, andons will be placed in the various parts of the plant. The measure can't solve the root of the problem but it is a feasible solution that mitigate the impact of alimentary dyes processing time. This proposal highly increases the flexibility of the system and reduce the lead time.

4.7. Setup Operations in Primary Production

Primary production has a lot of setup operations because of the high variability of the product to be produced. With the objective of reduce the time lose in setups it is important to decrease the setup time. To reduce the setup times SMED is implemented in the primary production. The main problem in the setup operations of primary production is the lack of mobility and accessibility in the area. This problem is caused by two aspects: 1) the interior of the primary production's room has a layout of tight paths because of the big quantity of shelves that store product in progress and raw material; 2) The corridor that allow the input and output of stocks in the primary production have too much circulation of people and materials.

To solve those two problems there are three proposals:

1. Use of visual management to define an area of the corridor just to transport material to inside and to outside of the production area; Besides this, the area of material transportation must be divided in two different paths, one to inside and other to outside, avoiding the disorganization caused by traffic in opposite way, in the same path.
2. Changes in the layout, decreasing the number of shelves and slightly increasing its height, not reducing the work safety patterns.
3. Once again, the kanban is a fundamental tool to increase the organization of the process and the efficiency in the management of the stocks. It will help to make the process more flexible and efficient.

Those measures allow the decreasing of setup times and the increasing of the satisfaction and productiveness of the workers.

5. Conclusions

In a summary, the solution proposal is very effective and allow the company to improve the efficiency and flexibility of the process, as desired at the begin. It will make possible to decrease the costs and continue with the expansion of the sales, raising the profit.

The reduce of costs and the possibility to continue the sales expansion are related with:

- Decrease of production time;
- Decrease of production cost;
- Increase of the workers satisfaction;
- Increase of workers productivity;
- Increase of the customers satisfaction.

It is important to refer the difference between the desired and the achieved. The methodology proposal refers to the use of three Lean methodologies and nice Lean tools. The tool levelling tool was not used in a direct way. It is explained by the fast changing environment where the company is included in. Because of that environment and progressively raising of the company sales, some changes were made in the company while the Dissertation was being produced. Besides that, as announced at the begin of the conclusion, the solution is robust in quality and flexibility.

It is mandatory to make sure the implementation is not just a set of proposals to implement in short-term. The main point of this solution is to give the tools and the right mentality to allow all the production teams to continuous improve.

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