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# Value stream mapping as a lean manufacturing tool: A new account approach for cost saving in a textile company

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**Abstract:** Companies around the world are under pressure to reduce their prices to be competitive. In order to keep profitability, they are adopting lean manufacturing (LM) and its tools to reduce waste and, consequently, the costs. Value stream mapping (VSM) is an efficient LM tool, identifying production flow waste. When it is possible to combine VSM with other LM tool, such as Kanban, a substantial impact in inventory reduction is reached. Additionally, the conventional account system shows limitations in the costs reduction to keep up with LM. The purpose of this paper is to present the results obtained by the application of the VSM combined with Kanban and the new account approach to measure the effectiveness of the cost reduction in the finished goods inventory. Considering that LM tools application in the textile segment has not an expressive number of researches, four hypothesis are presented and validated. The findings are discussed and finally, the research limitations and the practical implications originated by this work are presented as well as topics for further researches are suggested.

**Key words:** Value stream mapping, Kanban, Activity-based costing, Lean manufacturing, Textile, Lean accounting.

## 1. Introduction

In the last decades, many organizations in Brazil have implemented lean manufacturing (LM) tools with the objective of increasing their competitiveness. The majority of the applications were for discrete manufacturing (DM) systems in the auto-parts and automobile segments. A small number of applications were considered for continuous manufacturing (CM) systems in textile, steel and chemical segments. The first time the term lean was described was in the book *The Machine that Changed the World* (Womack, Jones and Ross, 1990), in which the solid gap between the mass production conception and lean production was exposed. One of the main features of lean is the focus on eliminating waste or *muda* (in Japanese) - all things that do not add value to the product or service under the customer point of view by the means of continuous improvement tasks.

A LM tool designed over the years was value stream mapping (VSM), which is used to manage and follow spot ways and identify and remove waste (Rother and Shook, 1998). It is meant to design the material flow through the operations, considering the whole supply chain, with the information of cycle time, downtime, and inventories and other key operations. Lopez *et al.* (2013) presented the value stream costing as an alternative costing technique as an approach to minimize costs in the lean enterprise.

Unfortunately, two key problems are encountered when talking about LM: most of the research that we have nowadays is based on the outcome of

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big corporations after introducing LM into their production line, and the preponderance of discrete manufacturing system (DMS) articles and the lack of continuous manufacturing system (CMS), as the case of the textile segment (Carvalho *et al.,* 2017).

One of the main issues introducing LM in Brazil is how predominant the traditional cost accounting methods are in the Brazilian companies and how behind their methods are. Most of these traditional methods clash in some way or another with LM. Big companies have already shown some type of resistance in introducing LM, while small companies, either, don't have the knowledge LM exists or are too comfortable to revamp and make LM a reality.

In this paper, we take a small textile company in a small town in Brazil as a case study. Its current manufacturing process (CVSM) and current cost analysis will be analyzed, and a future stream mapping (FVSM) will be introduced with the goal to minimize cost and maximize profitability.

This study aims to present a new account approach for cost saving validation considering a textile company in which had applied two combined LM tools in order to reduce its production wastes.

## 2. Research hypotheses

There is not a vast list of literature about the application of a VSM tool in the textile enterprise. A few articles can be found, such as Soliman (1998), which describes VSM as an important approach for process industry making it easier to identify where and how to improve. Some authors highlight the efficiency and validity of VSM as a Lean tool in a continuous process industry: Abdulmalek and Rajgopal (2007) in a steel mill, Ratnayake and Chaudry (2015) in the oil and gas industry, Seth *et al.* (2007) in a cottonseed oil company, Ragadali (2010) in a plastic extrusion segment and Palauro (2014) in a pulp production. In a similar way, all the articles explained points to be improved through VSM techniques in different industries. In a textile industry context, Hodge *et al.* (2011) observed that those who have implemented lean showed significant use of lean tools such as 5S, kaizen, kanban, "value stream mapping" (VSM), and "visual control". Panwar *et al.* (2013) studied the level of implementation of lean manufacturing in Indian process industries and found out that, even though, previous literature exemplifies VSM as a primary activity while adopting lean manufacturing (Seth *et al.,* 2007; Mahapatra *et al.,* 2006; Upadhye *et al.,* 2010), their study revealed that the use of VSM is not common in Indian process industries. In the rank of significantly used lean tools in Indian process industries, developed by them, VSM is the 16$^{th}$ tool out of 20. Considering the topics described above, it is possible to establish the following hypotheses:

**Hypothesis 1a**. Value stream mapping as an LM tool aids top managers to identify main wastes in the production flow.

**Hypothesis 1b**. Value stream mapping applied with other LM tool reduces the inventory impacting positively in the enterprise turnover.

The world is in a constant state of change and as the global market becomes more competitive companies need to rethink their strategies to attend consumers' needs. Companies not only have to keep up with multinationals but also need to maintain low prices without sacrificing product quality.

In order to be competitive, companies need to think outside the box and implement new methodologies and activities. A herculean improvement in the manufacturing process has been the addition of lean activities in a company. What started out as a way to reduce waste in manufacturing suddenly overtook all departments of a company, including the finance and accounting departments.

The purpose of implementing lean methods is to reduce waste or costs leading to increase in profit. As a result, the financial aspect of the company needs to be analyzed. In essence, there are two schools of thoughts relating the relationship between the implementation of lean and a company's net profit. There are several authors who follow the idea that the implementation of lean does not add to the company. However, authors, such as, Chenhall (1997), Easton and Jarrel (1998) and Callem *et al.* (2003) drew a positive association between lean manufacturing and financial performance. Following the connection of these authors and to illustrate this positive connection between them two, it is possible to outline the following hypothesis:

**Hypothesis 1c.** Implementation of lean activities makes the company more liquid, positively impacting net profit.

Finished goods inventory does not add to cost until the products can be sold (Carnes and Hedin, 2015).

 

Besides the cost to storage the finished product, the physical space needed for these products also hinders the possibilities for the business to expand or accept other ventures.

**Hypothesis 1d.** Implementation of lean activities decrease inventory freeing up space and expanding business opportunities.

## 3. The limitations of traditional costing systems

Most companies tend to use outdated cost accounting systems. These cost methods and systems have been used for years and have aided several companies to keep track of their costs and determine their product price. It is important to understand how they work and outline their flaws and limitations to better understand the need to move forwards and the lean transformation for a better fit.

### 3.1. Traditional Accounting Systems and the Overhead Problem

Traditionally, companies did their cost accounting with the solely purpose to supply managers and company's decision makers with the specific information needed to understand the cost of running the business and what paths to take based on that information. Differently than financial accounting, cost accounting is not subjected to General Accepted Accounting Principles (GAAP). Because of this exemption, several types of cost accounting systems were created. VanDerbeck (2010) explains that most of these systems use three main elements: direct materials, direct labor and overhead costs (indirect manufacturing costs). Combining these elements with traditional cost accounting methods, gave companies the ability to compute the total cost incurred in the year and the unit cost. Having this information benefits accountants to elaborate financial statements used by managers to better their planning and control over the company's life. However, complications can emerge since managers seek more efficient process methods while still relying on these outdated accounting methods, this conflict can yield distorted costs.

Martins (2008) explains how most Brazilian companies still rely on activity-based costing (ABC) and total absorption costing as their main cost system, which generates major conflicts as the companies implement new manufacturing methods. To understand this better, Lopez and Arbós (2013) illustrated it better in equation (1), which highlights how absorption costing systems or full cost calculates the per unit cost C of each product over a period of time, which accounts for the sum of all different materials used, plus all the direct labor cost and the sum of all the overhead allocated divided by the total units produced that period

$$C = \frac{\sum Material\ Cost + Direct\ Labor\ Cost + \sum Overhead\ Allocated}{Equivalent\ Units\ of\ Production} \quad (1)$$

Equation (1) can be misleading given that the more units the company produce the lower the unit cost. However, it does not necessarily mean all the products were sold on that period and that some of them are either still being produced in the inventory. To further examine the unit cost (equation (1)) the cost of material and the equivalent number of units of production (equation (3), where $t$ is the current period and $t+1$ is the next period) need to be calculated by using inventory and work in process (WIP), in order to better analyze if the company has significantly sold less products than it has produced:

$$Cost\ of\ materials_t\ Purchasest – \Delta Inventory_{(t+1)-t} \quad (2)$$

$$Equivalent\ units_t = Units\ completed_t + \Delta WIP_{(t+1)-t} \quad (3)$$

Even when taking into account the change in inventory it is observed that the increase in production will decrease the unit cost because the fixed overhead will be divided by a larger number increasing the company's gross margin. It might look better for the company but the company will suffer with high inventory in the case of its products becoming obsolete or not profitable anymore. Walther (2013) explains how arbitrarily choosing the allocation of overhead can either make or break a company's decision given that it is extremely hard to isolate the total direct costs of products given that companies, nowadays, produce multiple products and it has become more difficult to track direct costs.

Even with all the communication and information available online, it is worth mentioning the lack of introduction of new cost accounting systems in Brazil. A sheer amount of companies are still reluctant to adapt to even the smallest changes and still prefer traditional cost systems over improved methods such as lean or throughput system that reflects the implementation of newer manufacturing systems.

This is occurs especially with small companies, which still use outdated styles of manufacturing and cost accounting.

### 3.2. The demise of ABC

As companies expended and commenced producing a variety of products as opposed to only one, traditional accounting systems started becoming obsolete as it became harder to analyze the cost of several products at once. Furthermore, Johnson and Kaplan (1987) conceptualized the idea that cost accounting should account for more than just the cost of material, direct labor and overhead; every little action that in some way brought value to the product should be integrated as cost, even if had no-values attached to the cost of selling the product, that's when ABC was created.

ABC was created to fix some of the deficiencies created by traditional accounting systems as the companies became larger and the process of selling a product became more robust and more complex. Barfield, Raiborn and Kinney (1994) claim that consumers will not buy products if they perceive the product as not being cost effective or does not bring enough value to the price they are purchasing the product for. ABC uses a system that embodies every cost system termed "activities" that allocates costs and identifies cost drivers.

The cost driver problem is better comprehended in equation (4), which computers the unit cost *C* using the total amount of drivers and the amount of drivers consumed by the products in that period.

$$C = \sum Materials\ Cost + \sum \frac{(Labor + all\ other\ cost)}{Total\ amount\ of\ drivers} \times \times Amount\ of\ drivers \quad (4)$$

Even though, ABC is a revolutionary system, it still can't assign all overhead costs to products. The system's flaw is shown on the reliance on determining the 'right' denominator (Flanagan, 2008). The misuse of the wrong drivers will lead to unit cost distortions, which will produce inaccurate information. Krumwiede (1998) explains how ABC is not beneficial for every company. Smaller companies might not possess the resources to correctly apply ABC due to lack of time, IT resources, detailed information. Furthermore, this outdated system would negatively impact a small Brazilian company due to the system being focused on high profitability and the importance of all variables being integrated in the system.

As companies demand a more suitable cost system to complement their new manufacturing style, ABC started losing ground in the 1990's; even with authors such as Cooper (1996) contemplating the idea that ABC still supports JIT principles, other authors such as Kaplan and Norton (1992) completely discredit ABC and go as far as creating a better system that overtakes ABC. Huntzinger (2007) gives a more recent view to this topic, mentioning how the amount of resources needed (money, IT, accurate data, time), actually averts companies from using ABC systems.

## 4. Cost management for lean manufacturing

### 4.1. Lean Accounting Ideology

With companies adopting the lean methodology the costing system had to change to match this evolution. The Lean Accounting incorporates what obviously adds value to the product by eliminating or reducing everything else (Womack, 1990), which consists of waste and error elimination, capacity improvement and process acceleration. In essence, Lean Accounting eliminates wasted time and cost from the back office by simplifying systems.

The philosophy behind the Lean Accounting described by Womack and Jones (2003) mentions five fundamental principles that eliminate company waste: value creation, value stream analysis, optimizing flows, pull system application and strive for perfection. To start these principles, the organization needs to identify consumers' needs and expectations and derive the specific added values of the product.

As the second principle, Womack and Jones (2003) determine that all work be organized in value streams. Value stream consists of all activities a company needs to develop in order to sell a product, such as marketing, packaging, delivering, manufacturing, etcetera. This will generate a value to the consumer which will determine the profit of the company, besides highlighting the waste. Each value stream can be mapped with progress charts. From these maps, the company can design a first map that might include possible obstacles and waste and a second map that will provide the intended value stream status (Maskell and Baggarely, 2003).

The third principle regards optimizing flow, which Womack and Jones (2003) explains three types of flows exist: physical flow of material, information flow and cash flow. The purpose of this breakdown is to facilitate information and make it easier for all involved to work focused on improving these flows. Lean philosophy determines that all work must be separated by work cell. Each cell organizes workers and equipment together physically and functionally instead of departments. After being organized, the equipment is then placed in a sequence in a continuous flow. Womack and Jones (2003) explain that all workers must be trained to work on all activities and handle all equipment.

The fourth principle – the pull system – determines that the client will determine the level of production. Alongside this principle, the company also has to implement Just in time, which regards the company to obtain the specific part, and the specific place, and at the specific time (Boyle, Scherrer-Rathje and Stuart, 2011).

The fifth and last principle, strive for perfection, brings all the other principles together by specifying and identifying the right value stream, the company has a continuous flow for a specific product that will enable consumers to pick the best product for them. This endless cycle will generate a product that is the closest to what the consumers want (Womack and Jones, 2003). With the best possible product, the company will determine what the waste parts are and will be able to eliminate these processes from the flow. Kennedy and Brewer (2005) specify that the managers need to empower the employees to also improve the value flows for the consumers instead of exclusively relying on the managers.

### 4.2. The Evolution of Cost Accounting: The rise of Lean Accounting

The shortcomings of traditional cost systems led to a breakthrough in cost accounting that would aid and match the lean philosophy that companies started implementing: lean accounting. To complement the advances in lean manufacturing, “lean accounting aims to provide information useful to people who are implementing and sustaining lean manufacturing” (Maskell, 2000). As the second principle stands, VSC is essential for managers to implement lean accounting.

## 5. Methodology

### 5.1. The company´s profile

Founded in 1994, the studied company started its activities in the hot stamped sport shirts segments, when purchased the textile from the different sort of the suppliers. Looking forward to amplify its market share the company had started its own production in 1997, when started a new brand. In 2010, with strong investments in news pieces of equipment and installations, the company started its operations in the textile segment, when emerging a vast range of products, initially in the sport segment, focusing in the whole Brazilian domestic market. Located in the Paraiba Valley, Sao Paulo State, Brazil, the company currently has 22 employees, and produces 30 tons per moth of textile and stamps in average 4000 sport shirts monthly.

### 5.2. Method

The research work conducted in this paper was an exploratory case study. Regarding to the scientific approach this research can be classified as quali-quanti and applied as its nature. The data are collected during a period of six months when the company was operated in two shifts. The search of information was the field research and several meetings were conducted with blue colors employees, managers and the company board.

## 6. Findings

The first results of this work were regarded to the VSM elaboration for current production flow situation, reached in the beginning of this research. Managing the information collected from the production reports, the current value stream map (CVSM) was designed. A series of discussions among the researchers and the studied company´s top managers was conducted and Kanban was elected as the LM tool to be applied to reduce the main detected waste – finished goods inventory. After Kanban implementation, the future value stream map was designed. The results in the inventory level reduction were considering in a new account approach, and the results also are presented.

### 6.1. The current stream mapping

The next step is to draw the current state map which is done after the production flow observation. In Figure 1 there are some basic icons utilized in the mapping.

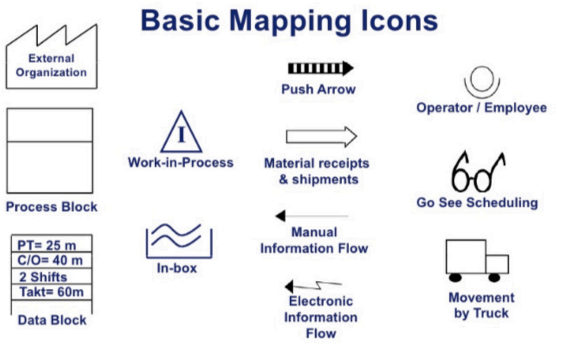


**Figure 1.** Basic icons used for mapping design.

Cycle time, inventory time and the number of employees in each position were collected by informal interviews with personnel during the visits to the textile company. And some data were collected as shown in Tables 1 to 5.

**Table 1.** Pieces produced (Embroidery).

| Machine 01 | Date | Machine 01 | Date |
|---|---|---|---|
| 407 | 01 August | 405 | 09 August |
| 117 | 02 August | 260 | 10 August |
| 250 | 03 August | 330 | 11 August |
| 350 | 04 August | 340 | 12 August |
| 230 | 05 August | 295 | 13 August |
| 200 | 06 August | 385 | 15 August |
| 220 | 08 August | 320 | 16 August |

**Table 2.** Pieces produced (Stamping).

| Date | Machine 01 | Machine 02 | Machine 03 | Machine 05 | Machine 06 |
|---|---|---|---|---|---|
| 01 August | 0 | 500 | 790 | 450 | 380 |
| 02 August | 520 | 550 | 260 | 420 | 420 |
| 03 August | 320 | 620 | 440 | 600 | 550 |
| 04 August | 210 | 200 | 180 | 210 | 200 |
| 05 August | 620 | 610 | 430 | 580 | 530 |
| 06 August | 550 | 440 | 670 | 520 | 510 |
| 08 August | 550 | 680 | 550 | 560 | 520 |
| 09 August | 280 | 220 | 210 | 180 | 200 |
| 10 August | 0 | 550 | 600 | 0 | 420 |
| 11 August | 620 | 610 | 440 | 500 | 580 |
| 12 August | 650 | 480 | 620 | 610 | 590 |
| 13 August | 350 | 490 | 660 | 480 | 520 |
| 15 August | 220 | 205 | 200 | 210 | 210 |
| 16 August | 480 | 520 | 440 | 520 | 520 |

**Table 3.** Embroidery non-programmed stopping times (minutes).

| Date | Busted line | Needle exchange |
|---|---|---|
| 23 August | 20 | - |
| 24 August | 14 | 2 |
| 25 August | 35 | 2 |
| 26 August | 36 | 2 |
| 12 September | 25 | - |
| 13 September | 11 | 4 |
| 14 September | 36 | 5 |
| 15 September | 38 | 5 |

**Table 5.** Embroidery Setup times (minutes).

| Time (minutes) | Pieces | Time (minutes) | Pieces |
|---|---|---|---|
| 15 | 150 | 22 | 300 |
| 7 | 100 | 7 | 100 |
| 10 | 200 | 8 | 100 |
| 16 | 200 | 7 | 100 |

**Table 4.** Embroidery Setup times (minutes).

| Top line Exchange | Bottom line Exchange | Glue and paste | Changing design | Line cutting/changing sides | Change line and sides | Changing frame |
|---|---|---|---|---|---|---|
| 4,5 | 10 | 51 | 12 | 72 | - | - |
| 3 | 17 | 49 | - | 52 | 8 | - |
| 1,5 | 32 | 28,5 | 6 | 39 | - | 6 |
| 3 | 38 | 33 | 7 | 38 | - | - |
| 5 | 10 | 45 | 15 | 60 | - | - |
| 5 | 18 | 55 | - | 55 | 9 | - |
| 2,5 | 35 | 30,5 | 8 | 45 | - | 8 |
| 5 | 35 | 35 | 8 | 39 | - | - |

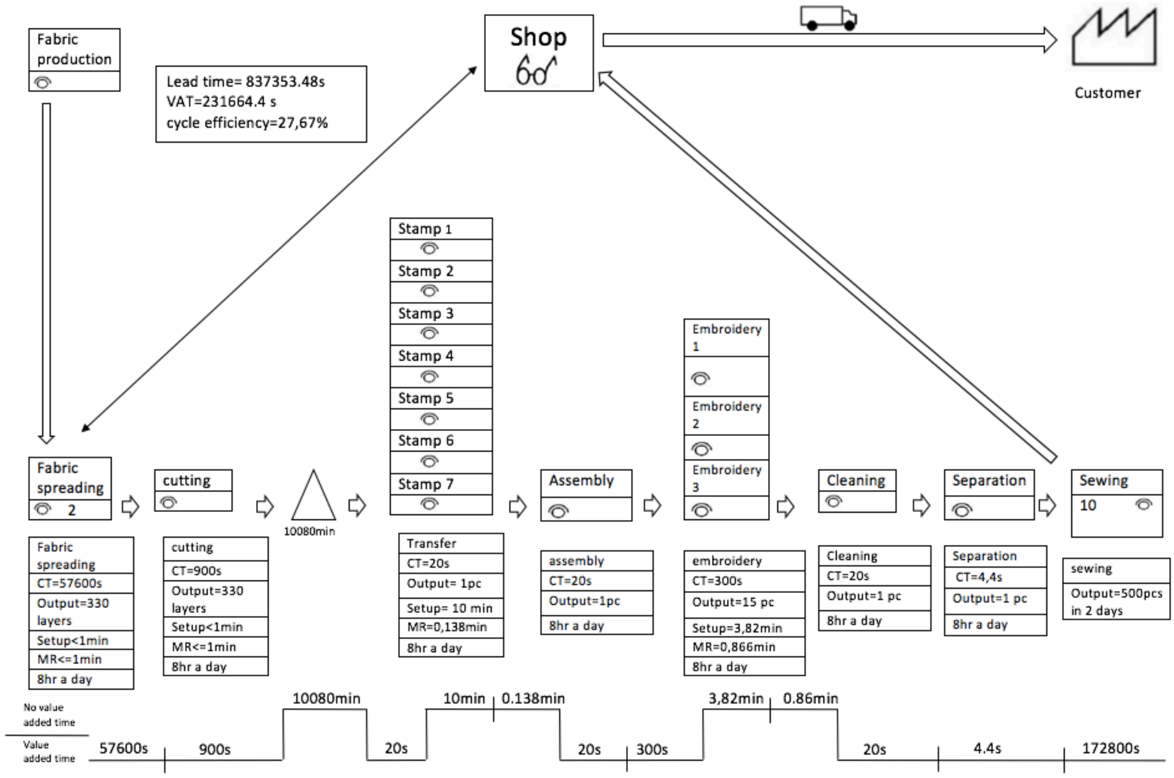


**Figure 2.** Current State Value Stream Map.

Based on the information described above the CVSM was drawn as shown in Figure 2.

As we can see in the map, the manager decides what will be produced based on their inventory in the shop and that is why we used the glasses icon, which means “Go see Scheduling”. There is no raw material supplier since the fabric is produced in the same company and goes directly to the first step of the production process.

The first process block of the flow is spreading the fabric and cut in layers, after this they cut it in the exactly sizes and format that the shop required. Then this “work in progress” stays about seven days until go to the Stamp machine. The assembly will basically do the preparation to the Embroidery that requires a specific assembly to be done. Than cleaning and separating the products to be send to the Sewing, which is outsourced. The number of employees is represented by the operator icon and if there is more than one it is written on the side.

In the Data Block we can find the Cycle Time (CT) which is the time spent to finish each process. The Output refers to the number of products produced at the end of one cycle time. The Setup time is the time to prepare the machine when the product that is being produced is changed. The MR is the machine repair which means period of time that the machine is not working for some problem in each CT, a not programmed maintenance. In the bottom of the map there is a time line presenting the time spent for one product get ready. The values presented on the top are non-value added times such as Setup time, MR time and stock time. The bottom values are value added times (CTs). Lead time (LT) can be found adding all the times, value added time (VAT) adding only the bottom values. Then efficiency of the cycle can be calculated by dividing VAT by LT. For the current state an efficiency of 27.67% was found, which is not a high value.

It was observed that some of the employees work in more than one process which can directly affect the productivity, for example the production stops when the truck is ready to be loading because the employees that are in production are responsible for the truck loading as well. There are a high number of stops for maintenance in the Embroidery process due to busted line and needle exchange. A relatively high setup time is also observed. A high MR and setup time are also present in the Stamping process which the main reasons are defective parts in the machinery, piston with problems, foam and Eucatex exchange. These reasons were all based on historical data provided.

## 6.2. Future stream mapping

Main wastes could be detected during the design of the current state map as shown in the Table 6 below.

**Table 6.** Main wastes detected in the CVSM.

| Type of waste | Process |
|---|---|
| Inventory | Between cutting and stamping |
| Waiting | Stamping |
| Waiting | Embroidery |

Due to these actions were chosen to minimize these effects. The future state map was designed through some improvements in the manufacturing process for T-shirts production.

Analyzing the most representative wastes, an action plan was designed to reach the inventory reduction, which is presented as follows:

- Kanban – The establishment of pull production concept should be conducted to the implementation of control of the finish goods inventory. The introduction of cards in the T-shirts store would be managing the master production schedule and as the consequence the work in process level would decrease.

Within the actions described above, the T-shirts future state map process is designed and Figure 2 shows the results.

Beyond the changes with the implementation of Kanban a reduction of 3 days in the inventory between cutting and stamping could be expected. After this action, the cycle efficiency increased to 40.1%.

## 6.3. Lean account application to the studied company´s production system

In the approach to apply lean account concepts, the company´s current and future stream mapping were considered, as well as, the following methodology to get the T-shirts production cost:

1. Computing physical values on the current and the future value stream mapping;
2. Evaluation of the capacity;
3. Research of the costs involved in the both value stream mapping;

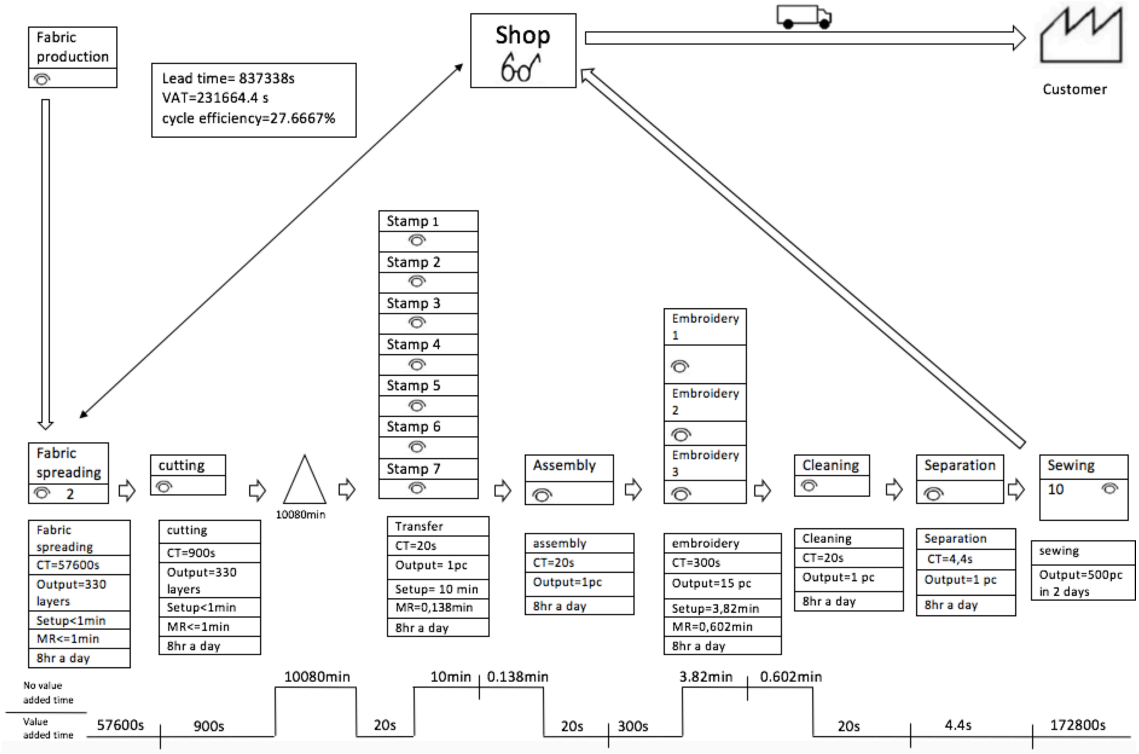


**Figure 2.** Future State Value Stream Map.

4. Accounting data collection;
5. Final comparison between the costs before and after the improvements implementation

To better understand the impact the implementation of LM tools had in the company's liquidity, the authors evaluated the total thread in stock of November, before implementing LM tools, this can be seen in Table 7.

**Table 7.** November Thread Stock.

| | kg | | Total Value |
|---|---|---|---|
| Thread 75/34 | 0 | 8.90 | - |
| Thread 75/36 | 16765 | 8.90 | 149,208.50 |
| Thread 75/108 | 0 | 9.38 | - |
| Thread 108/36 | 0 | 8.17 | - |
| Thread 30/1 | 466 | 8.90 | 4,147.40 |
| Total Thread in Stock | | | 153,355.90 |
| In Progress | | R$ 138,978.20 | |
| Finished in Stock | | R$ 661,067.16 | |
| Raw in Stock | | R$ 95,812.42 | |
| Total Stock | | | 1,049,213.68 |

The top managers of the company implemented Kanban during the month of December and to see whether the implementation of the LM tool had a positive or negative impact, the authors checked the total thread in stock at the end of December and compared with the previous month.

**Table 8.** December Thread Stock.

| | kg | | Total Value |
|---|---|---|---|
| Thread 75/34 | 8874 | 8.90 | 78,978.60 |
| Thread 75/36 | 0 | 8.90 | - |
| Thread 75/108 | 0 | 9.38 | - |
| Thread 108/36 | 0 | 8.17 | - |
| Thread 30/1 | 466 | 8.90 | 4,147.40 |
| Total Thread in Stock | | | 83,126.00 |
| In Progress | | R$ 111,675.31 | |
| Finished in Stock | | R$ 566,149.25 | |
| Raw in Stock | | R$ 53,647.78 | |
| Total Stock | | | 814,598.34 |

The December final thread stock shows a decrease in the final goods inventory worth R$231,615.34, proving that the implementation of Kanban and VSM had a positive impact in the liquidity of the company since all inventories (In progress, finished and raw) decreased after their implementation.

## 6. Conclusion

This article gave an understanding of how LM tools can be applied to identify wastes in a textile enterprise production flow. Value stream mapping showed the opportunities in waste reduction mainly in the final goods inventory. The work also reported the combined application of two LM tools: VSM and Kanban. To complement the investigation of this paper and the impact these tools have, both tools were implemented in the studied company and, in a short period of time, increased inventory turnover, impacting the operation profitability. The new finished goods inventory is lower than previously, with the same amount of assets, the company is, currently, more liquid since inventory is lower and profit higher (evening out the balance sheet). Low inventory also means more free space, which increases business opportunities because the enterprise has room to add new machinery or expand production.

The four hypothesis presented were validated by the results of this research work, but a limitation can be pointed because this study was conducted in one textile company only. As practical implication, the paper left a new guide for future account analysis regarded to the cost saving when LM tools are applied as well as opened a new field of approach for LM tools application as this case study, reducing the current researches gaps when it takes in consideration continuous manufacturing systems.

The group which had conducted this work, strongly suggests for further research a new approach by application of this acquired knowledge in different textile companies as well as in others which operate under continuous manufacturing systems as paper and steel mills.

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