Application of Value Stream Mapping in the Manufacturing Process of Amorim Florestal

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Abstract

Taking into account the current competitiveness of the global market and the high demanding consumers, which requires companies’ greater flexibility as a faster response. In fact, such industrial companies need to have production systems which have to quickly and efficiently accommodate these changes. It is therefore crucial that there are practical models to support the production processes reorganization. In this regard, we must point out the Lean principles that embrace a set of tools and methodologies which guide people and processes for added value in a continuous flow, by eliminating waste as well as the process shortcomings. Following the Lean Manufacturing production philosophy, a working method was developed, allowing the reorganization of productive systems by a Value Stream Mapping tool accordingly. The study case was carried out within the Coruche industrial unit of Amorim Florestal, more specifically in the raw materials Preparation sector. The productive system diagnosis was made according to the methods & times study, concluding with the presentation value stream map of the current state. Once identified the production system limitations and its waste sources, integrated improvement solutions have been established through the SMED, 5S, reduction of batch size and Kanban method. The obtained results highlight structural changes, regarding both working methods as process quality. This new approach establishes bridges between knowledge and the market place, additionally implementing the right environment for innovation in the future competitiveness challenge. This study proposes to render a more efficient and flexible company as well as produce more value added products.

Keywords: Lean Manufacturing, Value Stream Mapping, Method Engineering, 5´S, SMED, Kanban.

1 Introduction

Nowadays, due to the global markets competitiveness, enterprises must be ready for quick and needful changes. For industrial companies, this means that they have to be able to readapt all production systems as quickly and efficiently as possible.

This study has the goal to demonstrate, by applying Lean principles, that it is possible to turn more flexible, efficient and competitive the productive system of the Amorim Florestal, S.A.. For such purpose, and following the Lean philosophy, a working method which allows the production systems reorganization through the Value Stream Mapping Tool (VSM) was developed.

Through this approach, it was possible to redesign the future state value stream map from the current state value stream map, eliminating the identified wastes and applying the Lean principles to the Production Line 1 (LP1).

2 Historical Background

With the industrial revolution and the invention of the steam engine by James Watt, an era of economic growth was initiated and for the first time in history, the human working force was replaced by machines.

At the beginning of the 19th century, in order to meet the growing market need, Henry Ford, founder of Ford Motor Company, established a new production system called “Mass Production”. This production system expanded rapidly, revolutionizing the industry, still in use nowadays (Bhagwat, 2005).

Companies with a mass production system reduced costs and improved efficiency by increasing batch size, since the setup time was very high.

Meanwhile in Japan, Taiichi Ohno, chief engineer of Toyota Motors Company, has developed a new production system that mitigated one of the flaws associated with “mass production”. The system developed by Henry Ford could not respond to the
market's demand for diversified products (Riezebos, 2009). Thus, a new system was developed, initially known as Toyota Production System (TPS) (Ohno, 1988), capable of producing significant varieties of vehicles in small volumes and with a competitive cost, by changing the traditional mass production logic (Holweg, 2006). With the production lines flexibility it was then possible to reduce lead times, by decreasing the batch sizes, increasing the quality and by using the available space and equipment more efficiently (Likert, 2004).

3 Lean Manufacturing

The Lean Manufacturing was developed in order to maximize the use of resources through waste reduction. According to Ohno, any activity or process that does not add value to the client is considered wasteful and should be eliminated. The waste reduction is crucial to the Lean philosophy. Hence, seven types of waste were identified:

- **Overproduction** – It leads to increased inventory, decreases its rotation, increases the transportation costs and reduces the machines and space availability;
- **Inventory** – Higher levels of inventory implies higher capital employed and more storage capacity, and therefore directly impacts on company’s turnover ratio;
- **Waits** – Occur when the production is unfeasible and they essentially take place due to the lack of raw materials or breakdown in machinery;
- **Transportation** - Shifting of products which are not essential;
- **Excessive movements** – It consists in moving more than the necessary people or equipment;
- **Defects** – Final products that are not with the required specifications demanded by the customer. These defects may be related to losses in raw materials, machines or storage.
- **Reprocessing** - Additional operations that add no value to the final product.

Womack and Jones also identified an eighth waste, which is related to the people’s underutilization, specifically their ideas and creativity (Womack, 1996).

3.1 Lean Thinking

In 1996, Womack and Jones wrote a book with the purpose of publishing a cross-action guide to all industries. In this document, the Lean thinking has been defined as a 5-step process:

1. Set Value;
2. Set value stream;
3. Set continuous flow;
4. Synchronize production with demand;
5. Search for perfection.

Lean principles should be applied and adapted to industrial processes. However, for an organization to become truly Lean, it is not enough to reduce waste derived from operating activities. But it is also necessary to involve and coordinate product development, with the industrial process design, in order to establish a value stream and enabling the achievement of better results (Melton, 2005).

3.2 Lean tools

Lean Manufacturing is a process-oriented system, based on the implementation of a set of tools in order to identify and reduce waste. In this study, some of those techniques such as: Kanban, SMED, VSM, 5S and Kaizen, were applied.

3.2.1 Kanban

Kanban is Japanese for “visual signal” or “card” that is used to trigger an action. Technique developed by Taiichi Ohno to implement the just-in-time philosophy. System designed to control both inventory levels, as to regulate the production and raw material supply. This technique relies on the principle that only what is requested by the client should be produced.

3.2.2 Single Minute Exchange Dies (SMED)

SMED is considered to be a key method since under its scope it is possible to analyze the value-added activities and eliminate or convert the remaining ones; this because they do not add value to the product into the productive line. The SMED method was developed by Shingo in order to reduce and simplify the tool exchange duration.

3.2.3 Value Stream Mapping (VSM)

The VSM is a “pencil and paper” tool that helps the visualization and the understanding of the materials and information flow a product has made along the value stream. All process actions that increase or do not value the product can be identified with this tool. The VSM allows getting perspective of the entire value stream map, making it possible to identify not only waste, as well as its sources. The main goal of VSM is to identify all types of waste in the value stream and plan future improvements to eliminate them.

According to Rother and Shook, the VSM of the construction process consists of four steps (1999). Foremost, it is essential to identify the product that the VSM will improve. The second step is the design of the current state of the value stream mapping. As far as this stage is concerned, all non-added value activities must be identified.
Throughout the third step, the future state value stream mapping is designed by removing all activities identified in the previous step. Finally, a plan of action ought to be created in order to implement the proposed improvements. This plan is an interactive practice that should be analyzed, criticized and reworked to ensure continuous improvement (Kaizen philosophy) (Abdulmalek, 2007).

4.1.1 Methods Engineering

Methods engineering consists on the systematic recording and examination of the way the worker operates in order to make improvements.

The objective is the reduction of the work content of an operation, while work measurement is typically concerned with any ineffective time associated with the method and subsequent establishment of time standards for the operation.

Time Study is the analysis of a specific job by a qualified worker to find the most efficient method in terms of time and effort. Time Study measures the time needed for a task to be completed.

Motion Study is a technique for improving work methods and procedures. This study was based on visual analyses and interviews.

4.2 Result Analysis

4.2.1 Unfolding and Palletizing

This production sector is responsible for the cork planks separation in two major groups by grades and calibers, such as high calibers and thin calibers. In this process, the cork planks are separated by different calibers and grouped by qualities, separating sub-products (cork not apt for stoppers production). Subsequent palletizing in the appropriate carrier base takes place. This sector labors in 1 shift of 7,5 hours. It was found a 54.84% of occupancy rate and it works with 26% of non-productive time.

4.2.2 Cork Boiling

In this sector, the cork is boiled in autoclaves of 4 pallets. This sector labors in 3 shifts of 7,5 hours each. It was found a 52,78% of occupancy rate and it works with 24,2% of non-productive time.

4.2.3 Cork Stabilization I

In this operation, the cork is resting ideally for 24 hours, according to the CPIR1. Because this natural operation was considered 100% value added during the first 24 hours, the productive time is therefore 100%.

4.2.4 Tracing and Selection

This operation consists in the preparation of the boiled cork and the selection of different quality classes and size (thickness). This sector labors in one working shift of 7,5 hours.

A 97,60% of occupancy rate was registered and works with 26% of non-productive time.

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1 International code of cork stopper manufacturing practices.
4.2.5 Palletizing for Expedition

In this sector, the operators separate the cork in pallets for shipment. This sector labors in one shift of 7.5 hours. A 87.13% of occupancy rate was registered and works with 29% of non-productive time.

4.2.6 Steaming

This operation consists in the injection of dry and wet steam. This sector labors in 3 shifts of 7.5 hours each. A 92.36 % of occupancy rate was registered and works with 15% of non-productive time.

4.2.7 Stabilization II

This is the final operation of the productive system and the cork should rest ideally for 12 hours. As explained before in the section 4.2.3, this is a natural operation, so a 100% value added was considered during the first 12 hours, consequently the productive time is 100%.

4.2.8 Conclusions of Diagnosis

<table>
<thead>
<tr>
<th>Sector</th>
<th>Problem/Limitation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unfolding</td>
<td>• Push Production</td>
</tr>
<tr>
<td></td>
<td>• Receives isolated information derived from the Production control</td>
</tr>
<tr>
<td></td>
<td>• High inventory</td>
</tr>
<tr>
<td>Boiling</td>
<td>• Long and variable waiting time between processes (Unfolding-Bubbling)</td>
</tr>
<tr>
<td></td>
<td>• Long duration of Setup Time</td>
</tr>
<tr>
<td>Stabilization I</td>
<td>• High variability of C/T</td>
</tr>
<tr>
<td></td>
<td>• Compulsory Process</td>
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<tr>
<td></td>
<td>• Cycle Time is not fulfilled</td>
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<tr>
<td>Tracing</td>
<td>• High Occupancy Rate</td>
</tr>
<tr>
<td></td>
<td>• High Cycle Time</td>
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<tr>
<td></td>
<td>• Long Waiting Time</td>
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<tr>
<td>Final Palletizing</td>
<td>Cycle Time lower than Takt Time</td>
</tr>
<tr>
<td>Steaming</td>
<td>• Critical Occupancy Rate</td>
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<tr>
<td></td>
<td>• Long duration of Setup Time</td>
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<tr>
<td>Stabilization II</td>
<td>High variable Waiting Time to LP2 beginning</td>
</tr>
<tr>
<td></td>
<td>• Compulsory Process</td>
</tr>
<tr>
<td></td>
<td>• Cycle Time is not fulfilled</td>
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</tbody>
</table>

Table 1 – Diagnosis of LP1.

4.3 Solutions

In accordance with the diagnosis, it is necessary to apply methods that solve the identified problems in the production line.

In what concerns the analyses of the current value stream map (Figure 5), the following problems were identified:

- Push production;
- Nonexistence of communication between production sectors;
- Excess of inventory;
- Long waiting setup time;
- High occupancy rate;
- Long cycle time.

To tackle these problems, several methodologies based on Lean Manufacturing were developed.

4.3.1 SMED

The SMED method was fully applied in the boiling sector, nevertheless it also helped to minimize the setup time in the Steaming.

- Boiling Sector

The setup operation is a frequent process in the boiling sector and corresponds to one of the reasons that most contributes for the lack of flexibility of the production line. The preparation for changing pallets of the boiling tanks is an obligatory and extremely important process for this sector, performed daily over 3 dozen cycles. The operator takes on average 23 minutes to prepare the machine. This method has applied in 4-step process.

Step 0: Identify and categorize the operations.

In this step was identified all the activities in the process, and segregated in two categories: external operation - those items that have to be done while the machine is done; and internal operation - those items that can be done while the machine is running.

Step 1: Convert internal into external operations.

With this solution, the operator can anticipate the setup process while the machine is still working, therefore, the setup time could decrease in about 43.5%. This solution could be achieved by the implementation of Checklist.

Step 2: New practices development to transform internal into external operations.

According to what was observed, there is a lack of tools (steel chains), thus, after the boiling time,
operators spend a lot of time releasing the steel chains. Therefore, was suggested the acquisition of an additional pack of tools. With this solution would be possible to postpone an obligatory operation the decoupling of the chains, and convert into external operation.

**Step 3: Simplify the setup process for the both internal and external activities.**

- Improving the tool carrying
Currently there is no proper place for the tools (chains) storage after manufacture. Moreover, it appears that the handling of the tools is disorderly. The tools are placed on the floor after being used, and when necessary are dragged across the floor. Thus, it is suggested to purchase load carrier, to ensure a more efficient carriage, promote the organization of space, and when requested there already in correct position. With a mission to create a structured and organized work environment, this measure promotes standardization of procedures, which fits in 5S’ philosophy. With the application of this improvement, the time lost in transportation could reduce, approximately, four times.

- Parallelization of Tasks
It was observed that only an operator performs the setup operation. Therefore, it is recommended that operations are performed by two operators to be shortened the time of internal setup. This new method is intended to divide the operator's tasks and thus reduce its action zone, streamlining the process, as can be seen in Figure 3.

![Figure 2 - Application of the parallelization method.](Image)

- Application of the 5S' philosophy
As the boiling sector does not present clear and well-structured procedures, it is necessary to establish a set of rules which allow organizing the process of collecting and transporting the pallets. Therefore, seeking continuous improvement, it is fundamental to implement the 5S’ practice in order to create more appropriate environment to visual control, allowing the physical space planning. Consequently, it is suggested the creation of two separate areas (Figure 4). The yellow zone, located next to the autoclaves, is exclusive to the preparation of the pallets to be processed. The green zone is exclusive to the pallets already processed. By establishing two distinct zones, this measure is intended to eliminate a step so far necessary to empty the loading zone.

![Figure 3 - Implementation of 5S in Boiling Sector.](Image)

With this solution, the operation to move the boiled pallets for the stabilization sector and to carry new pallets to the immediacy of the tank are completely independent.

Thus, it is concluded that the application of SMED enables the reduction of non-productive time of the machine from 23 minutes to 6 minutes, reaching an estimated improvement of about 73.9%. The new setup time will only have a positive impact on the sector at the time when the external operations are executed before the end of production from all machines.

- Steaming Sector
The operator takes on average 10 minutes to prepare the machine.

With this solution, the operator can anticipate the setup process while the machine is still working, therefore, the setup time could decrease in about 40.5%, to 6 minutes. The new uptime is 86.4%.

**4.3.2 Improvements in Stabilization’s Cycle Time**

According to what was observed, the stabilization cycle time corresponds to 80% of the total manufacturing time and has great influence on the lead time of a batch. This being, the recommended time is not always accomplished because whenever the downstream sectors need raw material, the stabilization operation is interrupted. For instance, if a batch that has 100 hours of lead time and does not comply with the 24h stabilization time, then the customer delivery time reduces in about 20%.

There is no clear and effective procedure to ensure compliance and control cycle time, which is the reason why it makes the process unstructured. Thus, solutions must be pointed out to ensure that the stabilization time is met, and on the other hand, to improve performance evaluation of batches which are critical to production control.

In order to enable the cycle time two solutions were pointed out:
**4.3.1 First-In-First-Out (FIFO) in Stabilization II**

It was observed that the FIFO is not achieved in this sector. As verified in the following (summarize briefly):

- Excess hours at rest may be one of the factors that contribute to increasing frequency of stops, which means effective production time reduction;
- A few hours of rest, disc defective production in LP2.

Somehow, it is of paramount importance that the FIFO be applied in this sector, so that the stabilization time is fulfilled, to ensure that the raw material is manufactured in the best conditions. In what concerns FIFO implementation, it is suggested to empty such area of the warehouse, which is actually loaded with old machines. It is estimated that the release of this zone can increase by 21% the capacity of the warehouse. Thus, it is expected from the implementation of the FIFO Stabilization II to put in place the same stabilization time for all products and consequently the reduction of Lead Time variability.

In this sector, the products are stored according to type of product and production shift. Currently there are two types of these products, so it is suggested the creation of two FIFO lines dedicated to each product (Figure 6).
4.4 Value Stream Map - Future State

Corroborating the VSM methodology in this map for the future state (Figure 7) does not intend to complete a study, but only to be a starting point for further analysis and diagnostics. This enables the identification of new wastes and consequent elimination when found necessary, trying to attain perfection, as this is the philosophy held by Lean concepts.

The solutions enabled mainly to improve the quality of processes, reduce unnecessary inventory, reduce lead time and, consequently increased production capacity.

After the analyses of the value stream map, it demonstrates the following improvements:

- Pull production;
- Communication between productive sectors;
- Reduction of Lead Time;
- Decreasing the occupancy rate in unfolding, palletization and tracing sectors;
- Increasing the efficiency in the boiling sector;
- Improvement in the quality in the stabilization I by increasing the warehouse;
- Utilization of FIFO in the stabilization II, enabling the fulfillment cycle time of this sector and reducing the Lead Time.

It is possible to state that forces supporting Lean are always stronger then the opposite ones.

5 Conclusions

Through the diagnosis performed in the LP1, some limitations which influence the flexibility of the LP1 and responsiveness to market changes were identified.

The main setbacks are related to excess of inventory, lack of communication between sectors, sectors with high occupancy rate and high setup times between sectors.

With the recommended solutions, it was possible to deal with the problems objectively, bringing a new perspective of productive thinking and an innovative attitude to the Production Line 1.

The lean philosophy and its tools have proven to be a valuable aid in the proper approach to the constraints present within the production systems.

This philosophy serves both people and the entire business world, requiring a commitment of everyone to change a given situation. In conclusion, allow me to support the idea that without the synergy of all constituent elements of the production system its success would not be conceivable.

6 References

Figure 6 - VSM of Current State.
Figure 7 - VSM of Future State.