# LEAN APPROACH TO SUPPORT THE WASTE MINIMIZATION IN PRODUCTION PROCESS – A STUDY

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## ABSTRACT

This paper explores relationships between lean manufacturing practices, production management and knowledge management, with a proposal for a computational tool development. The key objective is to minimization of waste in the production process based on lean system. The article reviews the literature relevant to the construction of the computational tool, lean methodology, knowledge management and knowledge-based systems. It was used an exploratory and descriptive approach. The tool proposed is able to inform improvements in the production process. At a high level of management, the tool identifies and suggested improvements throughout the whole process. The relationship between value stream mapping and knowledge management is based on the development of a knowledge base containing information extracted from the value stream map, aiming to reduce the intermediate stocks from the manipulation of knowledge. The proposal is to reorganize and succeed in the management process, generating profits by minimizing waste identified by the value stream map.

**Keywords -** Lean Process, Knowledge Management, Production Management, Value Stream Map,

## 1. INTRODUCTION

Currently the companies have witnessed a growing increase in the level of market requirements. The challenges are many, such as increased competition, customers increasingly demanding quality services and technology advancement. Seeking to meet these challenges, companies try to find manufacturing systems that are appropriate to this new reality, through a combination of resources (skilled people, equipment, information systems and knowledge management) interdependent and interrelated, they should pursuing the same goals and whose performance may positively or negatively affect the organization. To achieve a positive performance in the face of current challenges, organizations need a plan of actions for the short, medium or long term, it may be more efficient to find the needs of customers with the management and use of knowledge (Kipper *et al.,*2011; Nara *et al.* 2012; Borh *et al.* 2012; Gibbons *et al.* 2012).

Slack *et al.* (2009) emphasize that all organizations should seek greater competitiveness from fulfilling their top five performance objectives: reliability, quality, speed, flexibility and cost which features present interactions and provide numerous benefits to organizations.

In this constant quest to attend these needs, companies set new structuring processes, in an

external way, treating the relationship with customers and suppliers, and internally, in respect of their management practices, especially in their lines production, which are one of the main factors that make up the costs of products. One of the most productive systems has excelled currently among large industries is the Lean Manufacturing (Duarte *et al.*, 2011)

From the mentioned needs, this article aims to propose the development of a tool with knowledge-based systems (KBS) containing information extracted from the value stream map and the collective experience of a production process. Thus, it is intended to achieve the reorganization of the management process, generating profits through actions for waste minimization appointed by value stream map.

For organizations to get success, it is necessary that their activities are managed and coordinated in a transparent and systematic way. The mapping process is a management tool that is intended to help to improve existing processes or deploying a new structure. Their structured analysis allows cost reduction, fault and improves the performance of processes, in addition to be an excellent tool to enable a better understanding of the processes contributing to the elimination or minimization of those processes that need changes (HUNT, 1996)

According to Maia *et al.(*2012), Lean Manufacturing is a tool that may assist in sustainable development. It is worth noting that the trend exists and that all stakeholders are trying to minimize waste generated in organizations. Lean tools such as VSM (Value Stream Map), 5S, Kaizen, TPM (Total Productive Maintenance), Poka-Yoke or other mechanisms would benefit to achieve these goals.

As the authors Duarte *et al.(*2011), in their case study, it is difficult to achieve the expected results using only one tool. In the case study proposed by the authors, it was used the concepts Lean manufacturing connected to SMED (Single Minute Exchange of Die) and 5S (Seiri, Seiton, Seiso, Seiketsu, Shitsuke) in order to increase productivity and reduce waste (Karin and Arif-UZ-Zaman, 2013). The paper is organized in the following way: section 2 discusses the Lean Manufacturing; section 3 shows the Knowledge Management; section 4 Methodology; section 5 the origin of production flow optimization and in section 6 is the conclusion.

## 2. LEAN MANUFACTURING

The main challenge for organizations is the involvement and identification of delivering of value to each customer and stakeholders. To get this challenge requires ability of companies to be lean in enterprising level (Carvalho, 2012)

The term Lean Manufacturing was popularized by Womack, Jones and Roos (2000) in the book "The Machine that Changed the World" published in the U.S. in the 90s. In this book, the advantages of performance of the Toyota Production System are clear, large differences in productivity, quality, product development, and it explains the success of the Japanese industry. In Brazil, this book was translated by Ferro at the time of publication of the book, when the word “lean” was adopted, referring to its efficiency by requiring fewer resources in a general way.

The system of Lean Manufacturing, in the vision of Ohno (1997), is the result of

minimizing the classic seven types of waste, also called losses existing within a company. Even as Womack and Jones (1996), Lean Manufacturing is a production system where the value is specific and obtained through the alignment of value-generating activities (...) It is a way to do more with less, looking to provide to the customers exactly what they need.

The basis of lean production is the combination of management techniques with technology in order to produce more with fewer resources. Lean production differs as much from craft production to mass production. In craft production, workers are highly skilled, using hand tools, manufacturing one product at a time. And in serial production or mass, professionals operate equipment with technology and specific purposes. In this case, the idle time must be avoided because of the machinery have a high cost. The role of management is to add a "reservation" in the form of extra stock and workers, to ensure availability of inputs for the production flow is not slowed.

So the main goal of lean production is the combination of the advantage of craft production, avoiding the high cost with mass production and avoiding the inflexibility. One of the fundamental concepts of Lean Manufacturing is the continuous improvement called Kaizen, considered key to the success of Japanese production methods. The production system developed by the Japanese is made to encourage constant changes and improvements as part of daily operations. To achieve Kaizen, the management leverages the collective experience (knowledge management) of all its employees and values the solution of problems together.

Lean Manufacturing has emerged as a manufacturing system whose focus is to optimize the processes and procedures through continuous reduction of waste, such as: loss overproduction, waiting time, for transport, for processing, for handling operations, defective products and stock. Salgado (1999), say that the elimination or minimization of waste in a company aided by value stream mapping may help to reduce the lead time of this process, since the implementation of value stream mapping enables to identify the waste inherent in the process and propose improvements in order to mitigate them, providing a reduction in lead time.

For the minimization of waste, lean production asset of techniques and tools like Cellular Layout, Kanban, the Value Stream Map among others. The great interest around the principles of lean production meant that this philosophy was applied in different organizations around the world (Santos *et al.*,2011). The diffusion of these concepts was so wide that the academic literature already has experience of applications of lean production in service operations (Piercy *et al.*,2009)and also in coordination with other management models such as Six Sigma (Kumar *et al.*,2006) and Agile Manufacturing (Krishnamurthy *et al*.,2007).

## 2.1 Value Stream Map

According to the authors Womack and Jones (1998), since the value for a particular product has been specified precisely, the value stream mapped, steps that do not add value are eliminated, it is essential that the value in the process flows, smooth and continuously, within the three critical management tasks: problem solving, information management, and physical transformation, making the process leaned.

The Value Stream Map (VSM) is one of the essential tools of Lean Manufacturing, which is the process of identifying all activities that occur in the processing of a particular product. Value stream is understood as a set of all activities occurring since the request of the order to delivery of the product to the consumer. It is a model for observing and understanding the current state and the drawing of a map of processes, is a visual representation of every process in the flow of material and information revising a set of key points and draws a future state map of how production should flow. Figure 1 shows a model of the value stream map of the company under study.The visualization of the tool is always performed from back to front, in other words, from client to the supplier, in order to minimize the personal influences in the process, ensuring that the flow is performed in favor of production.

As shown in Fig. 1 the flow of information starting on anticipated demand by customers, passing through sectors like sales for consolidation, Production Planning (Production Manager and PPC) for mounting on estimated production and manufacturing orders, Shopping for purchase of raw materials, suppliers delivery of the raw material, production transformation of raw materials into a product, and the shipping industry that delivers the product to the customer. So the customer is the first and last in the value stream map.

According to Rentes *et al.* (2004), to map the value stream is necessary to follow the path of production of a same kind of products from door to door of the plant, the consumer to the supplier, then, to draw the map of the current state of their material flows and information. Later, it is realized the future state map, noting the minimization of waste and generating a greater value to the customer.

The VSM provides besides minimizing the waste the optimization of the flow of manufacturing process, a number of other benefits that make it easier for top management of companies, knowledge and control of the production process (Womack *et al.*, 2000)

As the authors Araujo and Alves (2012), the VSM is a good tool that represents the flow of materials and information and it helps to identify the activities that are not adding value in the process. With this too, it is possible to check flows pushed or pulled, and the amount of stock at the beginning and at the end.The flows or systems pushed, as the name says, "push" the production, from the purchase of raw materials and components to the stocks of finished products. Since the system of "pull" production from the demand, producing at each stage only the necessary items, quantities and moments, was known in the West as kanban system (Correa and Correa, 2006).

## 2.2 The Seven Wastes

Lean Manufacturing is defined as a way to optimize production through several factors that, when they are aligned, allow an improvement in the performance of the production system as a whole. Among these factors are items like reducing manufacturing times and stocks, flexible, multifunctional workers, loss reduction and production pulled by demand and the constant quest to minimize any loss that does not generate value-added products (Ghinato, 2000; Smith *et al.*,2004; Womack and Jones,2004).

Shingo (1996), presents the study of the loss (or waste) on the production system and classifies them in seven types:

- **Overproduction**, referring to production of items more than necessary or in advance.
- **Transportation**, referring to activities moving materials or information, which usually do not add value to the product.
- **Processing,** referring to the activities of unnecessary transformation so that the product

acquires its basic features of quality, that is, in the job that generates unnecessary parts, details or transformations to the product.

- **Defective Products**, referring to the making of nonstandard items. This type of waste is perhaps more easily identifiable and measurable, but not the least important. One of the greatest needs of the modern companies is the endless search of excellence in production efficiency.
- **Motion**, related to useless movement in the execution of activities, in other words, it is the inefficiency of the operation itself. The measurement of this waste is linked to the achievement of performance standards for operations, and its elimination is achieved reaching the standards required and possible to implement, analyzing in conjunction the ergonomics of movement.
- **Waiting**, related to synchronization issues of the production or formation of large batch processing due to the high preparation time of the tasks, or failures in the information system of the organization. To avoid this waste, it is necessary to have access to the necessary information with accurately and easily, as well as investing in a reliable process and synchronized production.
- **Inventory**, related to the existence of the same, generating financial costs for its maintenance, costs due to obsolescence of items stocked and mainly opportunity costs for lost future market for competition with less *lead time*. The maximum possible reduction of stocks is a goal that has impact on organizational performance (Rentes *et al.,*2004)

In order to eliminate these seven wastes, Godinho Filho and Fernandes (2004), presented the tools applicable to the study of loss or waste of lean manufacturing, as Table 1.

Analyzing Table 1, it is noticed that the value stream map is a way to identify existing waste in the process.

| Tools / 7 Waste | Waiting | Transportation | Motion | Processing | Inventory | OverProduction | Defects |
|---|---|---|---|---|---|---|---|
| Value Stream Map | X | X | X | X | X | X | X |
| Working on Streaming / Batch size reduction | | X | X | | X | | |
| 5S | | | X | X | | X | |
| Working the Takt Time / Synchronitation the production | X | | | | | X | |
| Quality Control Tools | | | | | | | X |
| Zero Defect | | | | | | | X |
| Tools Poka Yoke | | | | | | | X |
| Total Productive Maintenance (TPM) | X | X | | | | | |
| Improvement in customer-supplier relationship | X | | | | | | |
| Working with Just In Time / Receiving and Delivery | X | | | | | | |

**Table 1 –** The seven wastes and their tools

## 3. KNOWLEDGE MANAGEMENT

Knowledge Management (KM) is, first of all, a new way of working, a new organizational culture, in which the environment and the values may generate the necessary motivation to learning, transfer and application of knowledge (Silveira, 2004; Accorsi *et al.*, 2012).

In the view of (Carvalho, 2012) knowledge management is in an organization through practices. However, it must be emphasized that knowledge management is not something that needs to be brought outside and implemented. A watchful eye on existing management practices in

any organization will reveal that many of them are practical knowledge.

One way to identify knowledge within companies may be using the tools of Lean Manufacturing as value stream map. Carvalho (2012) says that technology does not replace the knowledge, but that systems and information technology and communications are to support any management practices, including knowledge management.

The knowledge is being increasingly valued and has increasing importance for the competitiveness between organizations, increasing just as the demand for innovative and well prepared professionals, as well as the efficiency of the processes of these organizations (López-Nicolás and Meroño-Cerdán, 2011; Engeström and Sannino, 2010).

## 4. METHODOLOGICAL PROCEDURES

It was used an exploratory and descriptive approach to write this article. It is exploratory because it aims to provide greater familiarity with the subject performing data collection, reporting its true importance, the stage that it is and reveal new sources of information, involving bibliographic research. It is descriptive, because from the exploratory research will be conducted to assess the characteristics of a production process (Santos, 1999).

This study used the case study as data collection procedure, since it selects an object. In this case, it intends to uncover the management of a process with the use of value stream map, so that it is possible to develop a computational tool based on knowledge that allows an appropriate management decision to minimize waste in a production process.

The study begins with a value stream map of materials and information regarding the subject of the seven waste productions. Data will be collected and observed within the chosen process via spreadsheets, indicators, among others. It also begins parallel to this study a literature search. As research sources are considered: books, academic papers and scientific sites related to the subject.

Data are the following aspects: cycle time, rework time, demand rate, among others. With this information, they will be stratified by opportunities such as layout changes, movement and storage of materials, quick changes of tool. The diagnosis of the main sources of waste will be identified through the Value Stream Map. The value stream map is a tool that allows identification of material and information flow within an organization. Mapping helps to identify the sources of the waste stream value. After identified and prioritized the sources and types of waste, through the VSM analysis, improvement proposals will be developed using tools of lean manufacturing based on knowledge. Thus, this paper presents the initial results of this study.

## 5. THE ORIGIN OF PRODUCTION FLOW OPTIMIZATION

The Value Stream Map Current (Figure 9) identified improvements in various sectors of business, from analyzing the spot for making the map, and after its assembly there was waste in existing process and was a prioritized proposal for improvements as below:

- PCP sector

  - Lack of prioritization in production orders directly impacts the process with waste handling, waiting, inventory and transportation. Implement the system scheduled deliveries as production orders. The lack of prioritization of production orders often unnecessary impacts on efforts in production, and often having to stop a production line and change to meet Product shipments.

- Production sector

  - The process control is the essence of management, because the control is to ensure that established goals and objectives are achieved. The lack of an appropriate impacting whole operation. Implement the system on each workstation that controls the output per hour or shift intermediate stocks and rework, which help in prioritizing productions, controls help in the production estimate with actual data, planning is paramount to have productivity as real as possible.

  - The synchronization of production and reduction of production batches, one can observe the process much product waiting to be finalized, as mentioned previously, with the implementation of a control system would help identify these intermediate stocks, helping to eliminate or reduce them, as required for the next step.

In general, this proposal will help to improve the development of KBS and this, contributing significantly to the production process, reducing the intermediate stocks, timing of production and information management for better alignment of the process and reducing the flow that does not add value to the product.

### 5.1 System Development

The development of the vision of manufacturing involves the integration of technology to managerial vision, with the goal of developing a paradigm shift on the culture, processes, individual competencies, among others. The process of developing the vision of manufacturing is a process of organizational learning, as the organization prepares for new strategic choices and promotes the development of new ideas (Borh *et al.*, 2012)

When the VSM was created, the problem areas are apparent. The bottlenecks, inventory accumulation processes with low quality and operations that require excessive coordination should all be marked as explosion kaizen, which indicates areas of focus for FVSM (Future-Value Stream Map Future).

When developing FVSM, many assumptions are made about the changes that can be made in several areas, such as the design of work cells, kanban system design and configuration opportunities. The explosion kaizen indicates areas where it is necessary to formulate and implement changes and is indicated using the symbol shown in Fig. 2.

The processes marked with the explosion Kaizen, Fig. 3 are the areas where the problems become more apparent. The information system of the company generates a lot of paper documentation, has little speed / efficiency and lack of controls for monitoring primary production and intermediate stocks are relatively high.

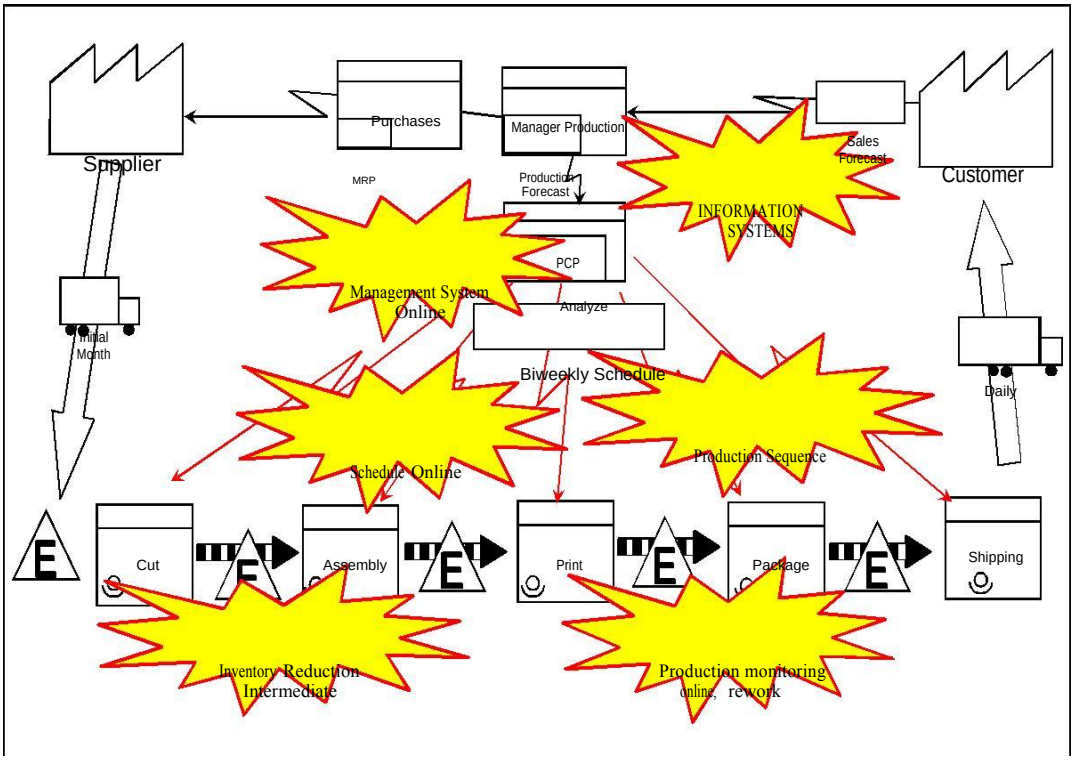


**Figure 3-** Proposed Improvements

The KM, understood the extent of their processes, developed in the following areas of intervention: the approach for strategic knowledge management, the content and structure; instruments / tools / practices and systems, organizational processes and management (Borh *et al.*, 2012). Maier and Remus (2003), considered two models in the implementation of knowledge management within a vision focused on processes:

- The management initiatives for process are conducted by a unit or for a specific project and may result in an approach based on resource management knowledge.
- A design knowledge management with a strong focus on business processes that are knowledge-intensive.

The goal of KM is not individuals and, yes, the organization. And one way to do this is by improving the performance of business processes, where workers at all levels can contribute (Hammer *et al.*,2004). This means that the organization should pay more attention to: training and development of employees; internal collaboration among employees, motivating employees and building relationships with suppliers and customers, in order to enable the development of skills, creation, transfer and use of knowledge (Hurtado *et al.*,2012).

According to Nonaka and Takeuchi (1997), the organizational knowledge creation is a continuous and dynamic interaction between tacit and explicit knowledge. This interaction is shaped by shifts between different modes of knowledge conversion.

From Fig. 4 it can be seen that the first phase is the mode of socialization is a process of sharing experiences and from that sharing is the creation of new tacit knowledge as mental models or technical skills shared in the case study of the VSM. The second mode is the externalization process of knowledge creation perfect as tacit knowledge becomes explicit in the form of metaphors, analogies, concepts, hypotheses and models (organizational training in Lean System). The third mode is the combination, is a process of systematizing concepts into a knowledge system involving a combination of different sets of explicit knowledge (development of KBS).

Develop KBS to help consolidate information relevant to the production process as production orders online monitoring production (productivity), rework, lost time, quantity intermediate inventories, assist in action plans as well as the tools of Lean culture (Management Visual, A3, kaizen, Poka-Yoke, among others).This system will allow managers to compare the company's expected future performance of FVSM lean system with the existing system, VSM Current. This comparison may be a good basis to support the decisions to be adopted by the managers of the company.

By using the methods discussed in Management for Process (minimizing waste), Information Systems (Knowledge Based Systems) and knowledge management, the proposal is to reorganize and succeed in the management process, generating profits through waste minimization pointed in VSM carried out at the wood.

### 5.2 Proposal the Computational Tool

The main reason to adopt a program of process improvement is to achieve a significant gain in quality, productivity, costs and gain control of the processes used by the organization. If the organization does not have a process control, this is reflected in numerous loss. Thus, there is a need to obtain a standardized process that permits the tracking and control of the production steps.

#### 5.2.1 Architecture of Tool

The tool was developed using the Java programming language web platform to make the system more accessible, including tablets, Struts2 framework and Postures database.

It has the following modules:

- Registration and Research: This is the first phase of the system, this section is necessary to register all machines, products, raw materials, process specifications of products.

- Planning: Planning is the second phase of the system, after registering all machines and

establish their productivity, register all products, raw materials, process specifications of the products.

- Production: The production is the third phase, it is all important information of what is happening in the "shop floor". These data bases will be reporting to the fourth phase, as well as important for the planning phase.

The Daily Board (Fig. 6) consists of operational, it is recorded everything that is happening at the time of a specific production. The diary contains the production order that is being produced to order of materials, construction, production date, shift and quantity of planned production and productivity held and stoppages in the process. This information is important for assembling progress reports and future forecasts.

Therefore, the demonstration of performance is critical to workforce planning for the future, make course corrections by analyzing the successes and failures of the past and visualize the future projections based on historical data or estimates of results. As mentioned earlier, the system is still in the development phase, and the data are not real.

## 6. CONCLUSION

This study aimed to propose the development of a tool based with knowledge (Knowledge-Based Systems - KBS) containing information extracted from the value stream map and the collective experience of the production process. The application of lean philosophy in the world of software development is closely related to the adoption of agile practices. Abandon old ways and habits is extremely necessary to combat a number of residues that are routine in most companies.

This article has only introduced the concept of Lean Management Philosophy or Lean principles, demonstrating how it may be interesting to develop a knowledge base and focused on the present issue of waste minimization, which is a key element of this philosophy.

The mapping process through Lean Manufacturing VSM tool helped identify the sources of process residues, which are analyzed: inventory, motion, waiting, transportation. Thus, this article used the tool Value Stream Map to identify waste and its causes in a production process. IT was observed a high rate of supply of raw materials at the beginning of the period stipulated by the company, but this does not solve the need for raw materials during the period of analysis. It was identified various production stages, confirming the existence of intermediate stocks of by-products in all activities.

In Table 1, it is possible to analyze the proposed improvements identified in the value stream map in Fig. 3, which residues will be minimized in the process. Fig. 4 and 5 shows the basis for the construction of the organizational knowledge base, starting with the preparation of the VSM and the identification of waste by means of strengthening the organizational capacity to support systems (KBS) and applying the knowledge to minimize waste in the process. Moreover, research has indicated a number of opportunities that could be exploited from the full implementation of the Lean Manufacturing principles.

In addition, there is a certain difficulty for companies to find a system that helps companies implement and control Lean Manufacturing principles, and this aspect deserves attention from researchers. The next step and finish the computational tool and apply it in a production process. This knowledge base will propose a new look at the case management, especially in identifying waste and its solution.

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