Process improvement in Pharmaceutical Industry through Kaizen Lean Methodology

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Abstract – Last decades registered huge technological progress in industrial processes. These advances are reflected in a large decrease of costs in production lines, which, combined with a strong competition, causes a huge reduction in the prices of the final products. Hence, the major concern of industrial managers is to reduce the maximum costs related to the production. Kaizen Institute (IK), the company through which this Project has been carried out, is the world's leader in the implementation of the Kaizen Lean method. This method has its origins in Toyota Production System (TPS). The use of Kaizen Lean method, by mapping the value chain and the selection of activities and tasks that add value, improves the processes of production, searching and eliminating muda (waste). This paper considers a production flow and internal flow problem of Empresa X, current leader in the production of drugs in Portugal. The problem lies in both company's plants and the aim of the project lies in the optimization of both logistics and production processes and internal flows, using some tools of Kaizen Management System (KMS), integrated in Total Flow Management (TFM) pillar. Through the implementation of SMED in the packaging area, it has been possible to increase considerably the efficiency of the equipment and reduce the average changeover time to less than half. The implementation of Daily Kaizen and several improvement suggestions resulting from it were conducive to the positive results obtained in most of Empresa X Industrial area KPI's.

Keywords *– Pharmaceutical industry, Kaizen, Lean, Muda, Total Flow Management.*

1 Introduction

Nowadays the market is marked by the constant changes occurring on a daily basis due to the fierce competition as the companies strive for increasing their product quality and reducing the associated costs. With all the concern about reducing the costs and eliminate the waste and despite all the technological innovations, companies continue to lose costumers due to the lack of service level caused by these same cost reductions (Bonaccorsi, 2011).

Thus it has become increasingly essential to continuously improve the processes in the process industries. Therefore, reducing cost and waste without jeopardizing the quality or the service level is a high priority, as both the customer and the company will benefit from the changes. Currently the most appropriate and known methodology for such improvement was developed as the Toyota Production System and is called Lean Manufacturing or Lean Production. (Dotoli, 2011).

One of the most common ways of implementation of a Lean Production methodology is the implementation of a *Kaizen* system, Japanese word for continuous improvement system that is based on five main principles, described by Masaaki Imai as the foundations of *Kaizen*: creation of value for the costumer; the identification and elimination of *muda*, Japanese term for waste that according to Taiichi Ohno is any activity the customer is not prepared to pay for; people involvement at all levels; go to *gemba*, Japanese word for shop floor, to get good data and create awareness and making processes and waste visible (Kaizen Institute, 2013a).

In order to sort the waste, *muda* is represented by a model that contains seven types of *muda*: too much production; defects scrap; people waiting; people moving; material waiting; too much processing and material moving (Imai, 2012).

The Pharmaceutical industry is one of the most developed industries in the previous decades It has been diversified and globalized in order to reduce the costs associated (Cardinal, 2001). Given all the quality regulation and health specifications in the industry there is still a high level of waste in the end-to-end process with excessive check, cleaning and preparation tasks which generates all kinds of *muda*.

Empresa X is a Portuguese pharmaceutical company which leads the market for the production and sale of drugs. With two production sites they are aiming for improving their market share and profit margins through the implementation of a continuous improvement system.

In order to achieve their goals they partnered up with *Kaizen* Institute for the implementation of *Kaizen* Lean methodologies as a way of reducing the waste through the value stream chain.

This paper goal is to put forward the different phases of this implementation, starting with the definition of the initial state with the collection and analysis of data that will provide a solid basis for the implementation of the solution based in Lean tools.

Section 2 contains a bibliographic review on Lean and Lean Production as well as some Lean Tools. Section 3 encompasses a short presentation on the case study, with the description of *Kaizen* Institute, Empresa X and the main problems that under analysis. Section 4 introduces the methodologies implemented in Empresa X as well as the steps taken in the implementing process. The purpose of Section 5 is performing the evaluation of comprises the major conclusions of the paper.

2 State of the art

2.1 Lean / Kaizen

Lean is a production philosophy developed by the Japanese company Toyota as the Toyota Production System focused on generating a continuous flow and reducing the waste through the value stream chain (Womack et al., 1990).

As written by Ohno (1997), Lean was based in the Just-in-Time methodology with a main concern on the activities that add value to the client aiming to eliminate the *muda* and reducing changeover times and stocks over the supply chain.

According to Melton (2005), the Lean philosophy is an industrial revolution that completely changed the managing concepts through the companies by modifying the main work habits.

Lean is based in three main principles: identification of added value activities, elimination of waste and the creation of a continuous value stream (Womack and Jones, 1996). In order to apply these main principles Lean philosophy has taken advantage of some industrial key practices such as Total Quality Management, Total Preventive Management, Total Flow Management and Just-in-Time (Shah e Ward, 2003).

Melton (2005) states that in order to successfully implement a Lean methodology in any company it is required to follow an approach based on continuous improvement. This approach follows a basic structure comprised in five main steps as can be seen in Figure 1. The approach described by Melton starts with the observation of the current processes identifying which ones are considered value added activities or waste activities, in this step it is essential to involve the people who run these processes in a daily basis in order to use their knowledge. Based on the data collected in the previous step and using cross-functional teams, a data analysis is carried out as a diagnose of the issues through the processes. After analyzing the data, a change will be designed involving elimination of waste or creation of new sustainable processes. Once the change is planned, the new process is implemented with training and the ability to monitor the changes. At last the benefits are evaluated and data should be collected in order to perform any further changes needed.

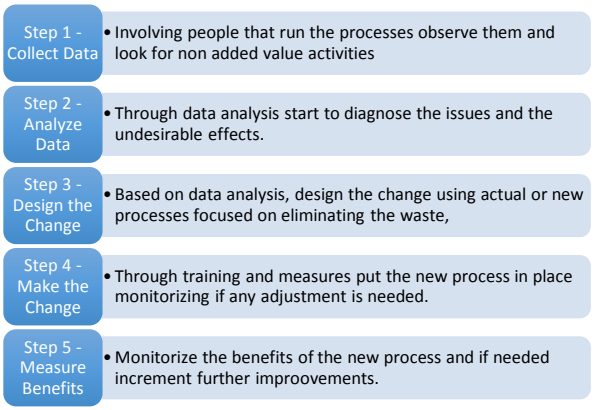


Figure 1 – "How to Lean"
Font: Melton, 2005

So as to understand Lean it is necessary to learn and to notice the Lean tools among which the Kaizen methodology. Kaizen and Lean are often confused and seen as one but in reality they are distinct, Lean is a goal to be achieved, i.e., the total elimination of waste, while Kaizen (Kai - change, Zen - as well), is the Japanese word for continuous improvement and is the tool used to achieve Lean (Ortiz, 2010).

Kaizen adapts common sense to real life situations. It requires little investment and is focused on reducing both material and labor waste. *Kaizen* methodology also supports the organization leaders to motivate and involve the employees in achieving continuous improvement in their *gemba* so they can increase productivity, quality and/or safety. It is only possible to do *Kaizen* if everybody is involved every day and everywhere (Mano et al, 2013).

Kaizen includes making changes as well as measure the results (usually using key performance indicators)

and subsequent adjustment. A *Kaizen* known as an event in which people are focused in implementing Lean tools, may include the participation of employees at all levels of the organization, including cross-functional teams of workers involved in the different parts of the process, so the dependency between tasks can be displayed in order to create new synchronized improvements suggested by people who actually do the work (Chera et al., 2012).

2.2 Lean Production

In the early 40's, the Japanese automotive industry went through a period of great difficulties, both financially and in terms of production. It could not compete directly with European or American players (Cusumano, MA 1988). Therefore, and in order to regain competitiveness, companies in the automotive sector, led by Toyota, began developing new methods of automobile production, based on observing the sector leaders such as Ford and General Motors (Cusumano, 1989).

The methods developed by the Japanese companies originated the Lean Production, which is characterized as an intellectual approach constituted by a measurement system and methods which together have the potential to make a company Lean and thereby make it more competitive. This methodology can be applied not only in manufacturing areas, but also throughout the company and is divided by the author into four fields of action: product development, supply chain management, workplace management and post-sale services. (Warnecke Huser, 1995)

One of the main goals of the Lean production system is the production of small batches, using Pull planning i.e. producing the necessary material along the chain, using *kanbans*, i.e. cards with orders, production sales, etc. (Melton, 2005)

Womack et al. (1990) argue that Lean Production is not only the most efficient system of production in the automotive industry as well as one of the best ways to organize any type of industrial production, recording large increases in productivity and huge improvements in working conditions. Womack et al. also describe that the Lean production system also gives advantages related to worker autonomy, participation of all stakeholders in continuous improvement and training of workers.

The case study by Chen et al. (2013) tested the implementation of a Lean production system in the supply chain of a logistics company as to improve the material and information flows and concluded that with the implementation the time of operation was reduced in 81% with the waiting times being the most affected. The implementation of Lean Production resulted in a significant reduction of labor costs, maintaining capacity and the level of service.

In order to apply successfully Lean Production it is necessary that the Lean tools and techniques are chosen and always implemented with the concern that their practical application is appropriate in each case (Imai, 2012).

2.3 Lean Tools and Techniques

Giving to the Seven Muda Model one of the main steps in the implementation of a *Kaizen* system, is the selection of the suitable tools for the application of Kaizen methodology in each company or industry (Imai, 2012).

Based on articles published by several authors, this sections presents information collected on some Lean tools as well as the examples on the application of these tools.

- **Kaizen Strategy Planning (KSP)**

Kaizen Strategy Planning (KSP) is a tool developed by Kaizen Institute whose main objective is to design and plan the program of continuous improvement and cultural transformation of a company or organization. The KSP is directly related to the mapping and planning of the organization's value chain and is a simplification of the VSM in the following four phases: analysis of the current situation, in which the objectives and scope of the strategy are clarified, with the quantification of the current state and identification of the improvement suggestions; overview of Kaizen Strategy, which consists of the prioritization of the initiatives proposed in the previous stage; Strategic Improvement Plan – planning possible actions to implement in a short term period; and follow-up, creation of a mission control room and reflection of the lessons learned in order to increase knowledge (Kaizen Institute, 2014).

The main focus of this tool is the development of a strategic plan for continuous improvement through demonstrating how to improve QCDM indicators (quality, cost, delivery, motivation) and explain the role of leadership and support of a continuous improvement program supported (Kaizen Institute, 2014).

- **Five S (5S)**

The 5S is a tool that aims to shop floor organization and contributes to good condition and functionality of all workplaces, by cleaning, housekeeping and disciplining (Melton, 2005).

Like the name indicates, the tool is divided in five steps: sort (*seiri*) – remove unnecessary items; straighten (*seiton*) – arrange the items so they can be easily picked; shine (*seiso*) – clean the workplace; standardize (*seketsu*) – maintain the three previous

steps; and sustain (*shitsuke*) – keep all the standards in order (Imai, 2012).

- **Visual Management**

The goal of Visual Management is to visually identify the area of work. It is used not only to help communicate, but also to help highlight anomalies and to avoid making mistakes (Tenera e Pinto, 2014).

The improvement of visual management is characterized as one of the most effective Lean tools and one of whose impact is felt quickly, as its effective application to production systems contributes to the rapid increase of the main indicators of performance: safety, quality and productivity, acting as an interface between employees and production system (Murata and Katayama, 2010).

- **Single Minute Exchange of Die (SMED)**

SMED was developed by Shingeo Shingo at a time Taiichi Ohno was implementing Just-in-Time in Toyota, One of Taiichi Ohno's main goals was to produce smaller, more frequent batches in order to create flow and eliminate stocks. In this context he hired Shingeo Shingo with the purpose of reducing the changeover times with the intention of producing smaller batches without reducing the productivity (Ferradas & Salonitis, 2013). SMED methodology is divided in five steps: observing the current methodology; separating the internal and external activities; converting internal activities to external; reducing the internal activities; and finally reducing the external activities (Shingo, 1985).

After combining these five steps, Shingo reached surprisingly positive results in reducing changeover times, but the overall success rate was only attained when all the people whose duties were involved in change were included, such as the cleaning crew, the maintenance team, the quality department and all suppliers of materials and tools needed to implement the changes. Hence, it is concluded that it is not only necessary to study the methodology but also attaining the commitment of all employees involved. (Almomani et al., 2013)

In a case study developed by Ferradas and Salonitis (2013), implementing the SMED tool in welding cells, according to the authors, after implementing SMED they obtained considerable success, registering 33% reductions in changeover times, without any tangible investments.

- **Kanban**

The Kanban system was developed as a subsystem of Toyota Production System with the objective of controlling inventory levels, production orders and the supply of components and raw materials. Kanban is defined as a control mechanism that improves material flow and monitors the production of the required products in the right amount at the right time (Lage Junior e Godinho Filho, 2010).

The six tools presented above are the basis of this paper showing the implementation of Lean Production system in Empresa X aiming the reduction of changeover times and improve the internal information and material flows.

The following sections presents the case study as well as the implementation and follow up of the Lean tools.

3 Case Study

Empresa X is a pharmaceutical company that produces and distributes drugs. It has two facilities, both located in the Greater Lisbon area.

The work developed in this paper is focused in the company's industrial area and specifically in the packaging department which is the bottleneck of the productive process.

The packaging process is divided into two main processes, each of them sub-divided in four, thus obtaining a total of eight sub-processes as presented in Figure 2.

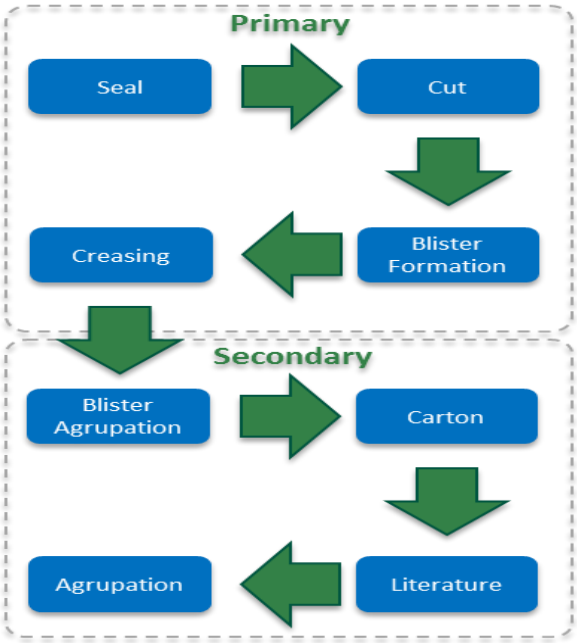


Figure 2 - Packaging Process

The main processes performed by the operators in this area are related to the transportation and provision of material into the packaging machines and complex changeovers of machine tools and parts. This requires coordination and training due to the complexity of the operations involved in the machine setups.

In the packaging area there are four lines and in which one there are two operators working steadily. Additionally, there is a logistic operator per shift who is responsible for the transportation of material and activities related to computer systems.

Through the *gemba* analysis, several problems were identified, such as major flaws in the creation of an internal team spirit, a weak organization of spaces, long changeover times and a large number of production stops due to the lack of internal flow within the factory. Thus, it was concluded that the main points to take into consideration for the implementation of improvements in the future were: the creation of Daily Kaizen teams, the implementation of 5S and visual management tools, creating flow in production and internal logistics, changes in product line, both in production and in packaging, autonomous maintenance of the lines by operators, preventive maintenance and creation of an internal flow in the plant department.

In order to improve the processes described above and to solve the identified problems, Empresa X decided to implement a continuous improvement system. To implement this system, the model chosen was the system developed by *Kaizen* Institute, *Kaizen* Management System (KMS).

KMS is based on the Lean principles or foundations described in section 1, always aiming at the waste elimination.

As a transversal pillar the *Kaizen* Change Management (KCM) was developed, which includes Daily *Kaizen*, Project *Kaizen* and Support *Kaizen*.

KMS is then divided in five pillars with which one aimed at its name: total flow management (TFM), total quality management (TQM), total productive maintenance (TPM), total service management (TSM) and innovation and development management (IDM).

In this paper the *Kaizen* Change Management is implemented with the goal of creating a continuous improvement culture over all the company. The TFM and TPM will be also used in order to create flow in the internal logistics of the packaging area and to solve some maintenance and machinery problems.

In short, this paper aims to organize the industrial area teams and increase the processes efficiency and productivity in the packaging area by creating internal flow, reducing changeover times and organizing the shop floor. In order to achieve this goal some Lean tools will be implemented.

4 Application of Kaizen Lean

As developed by Melton (2005), the application of a Lean methodology in an organization is divided in the five steps presented in Figure 1.

In the present paper this structure was consolidated in three phases: data collection and analysis, implementation and follow-up. The first phase describes the collection and analysis of data that will be the basis of the improvements applied in the following phase. The second phase displays the process of implementation of the improvements. Finally, the benefits are measured in the follow-up phase.

4.1 Data collection and analysis

This paper started with an observation of the current state in order to identify *muda* and improvement opportunities. For this, the author collected and analyzed the data referring to the industrial area key performance indicators and packaging area processes.

With the scope of realizing a structured data collection and analysis and to design consistent solutions and planning a *Kaizen* Strategy Planning Workshop was performed.

The KSP Workshop begins with a review and analysis of the current situation, based on the data collected along the section, with the purpose of defining the areas where changes should be implemented. In addition, it is also possible to realize the impact that each area has on the company growth goals. With this analysis it is possible to set QCDM goals based on the current situation.

In order to effectively establish a comparison state, follow-up the changes and set the goals some Key Performance Indicators (KPI's) were defined, both in the industrial area and in the packaging area, in this paper it will be only considered the main KPI's defined:

- **Global Overall Equipment Effectiveness (OEE):** it is intended to monitor the overall efficiency of all the equipment dedicated to the production and packaging of the drugs.

$$OEE = \frac{\sum_i (Yi \times Tcti)}{\sum_i Tai} \ (\%) \qquad [1]$$

OEE value is obtained by summing the product of the number of good units produced in each batch (Yi) by the respective theoretical cycle time (Tcti) divided by the sum of the opening time (Tai), i.e. the stipulated time to produce, for all the batches.

- **Productivity:** This indicator measures the number of units produced annually by FTE (full time employee).

$$Productivity = \frac{Units\ Produced}{Number\ of\ FTE's} \qquad [2]$$

The productivity is obtained by dividing the annual production of drug units per FTE (taking into account all Empresa X FTE's).

- **Unit Cost (direct + indirect):** represents the average unit cost associated with the production of a medicine box, and takes into account all direct and indirect costs in which Empresa X incurs to produce the box.

$$Unit\ Cost\ = \frac{Total\ Cost}{Units\ Produced} \quad [3]$$

It is obtained by dividing all Empresa X's cost related with the production of the medicine box by the units produced.

- **Plant cycle time:** represents the average time from the beginning of manufacturing a product by the end of its production, namely, the average lead time for production**.**

$$PCT\ = \frac{\sum_{i=1}^{n} LT_i}{\sum_{i=i}^{n} O_i} \quad [4]$$

It is calculated by dividing the sum of the lead time for each order (LT_i) by the number of orders (O_i).

- **Average changeover time (ACT):** this KPI concerns only to the packaging area. It represents the average changeover duration in the packaging lines.

$$ACT\ = \frac{\sum_{i=1}^{n} Ts_i}{\sum_{i=i}^{n} S_i} \quad [5]$$

It is calculated by dividing the sum of setup time (Ts_i) by the total number of setups (S_i).

After defining the key performance indicators proceeded to collect the data for each of them, as well as the global impact that each has on the company growth in order to be able to set targets for each indicator and then define the areas of performance and the main improvements to develop, the results are presented in Table 1:

Table 1 - KPI's current state, goal and impact

QC DM	KPI	Base	Annual Goal	Impact
C	OEE	44%	≥ 55%	5
C	Productivity (U/FTE)	385.682	≥482.103	5
C	Unit Cost	1,16€	≤ 0,99€	5
D	*PCT*	64,3 d	≤ 58 d	3
C	ACT	04:14:29	02:00:00	

As presented in Table 1 the KPI's chosen for the follow-up of the developed work are mainly focused on efficiency and productivity, as to achieve them there were planned several workshops for the implementation of improvements described below.

After the process of collecting and analyzing data, it was possible to determine and plan several actions to improve throughout the industrial area of Company X. The workshops that were planned to implement over this this are related to the monitoring KPI's defined for industrial area and the packing area, meeting these directly related to operational efficiency. Through the analyzes in gemba, there were identified major flaws in the teamwork habits, incipient organization of spaces, extended changeover times, too long downtime and a lack of internal flow within the factory.

In order to solve those problems and to achieve the goals presented on Table 1 it was planned to start with the implementation of Daily Kaizen, followed by SMED, the maximum yield of the area of packaging and Standard Work. There shall be parallel implementations regarding to the work follow-up which includes the construction of the control room and the implementation of the follow-up meetings.

Completed the planning phase, it will be presented the implementation phase of the identified improvements and the respective follow-up.

4.2 Implementation

Phase 1: Daily Kaizen:

In the first phase was implemented the first level of Daily Kaizen which consist in organize the natural teams, by creating standardized team meetings, supported by the Daily Kaizen board team, which features several elements of support to the team at the time of the meeting.

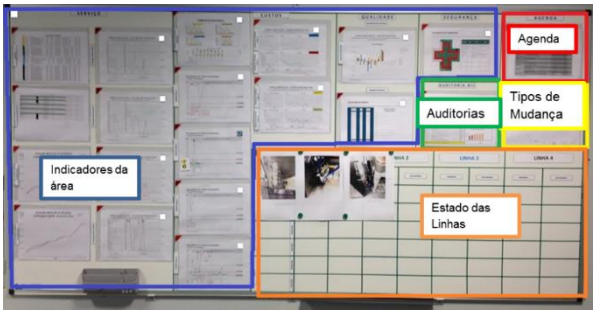


Figure 3 - Daily Kaizen Frame

As one can see in Figure 3 the Daily Kaizen framework using Visual Management, contains the meeting agenda (red area in Figure 3), the indicators of the area agenda (blue area in Figure 3), the characterization of the changes agenda (yellow area in Figure 3), the outcome of the audits agenda (green area in Figure 3) and the current state of the lines agenda (orange area in Figure 3), ie, what are the problems that produce and present.

With the implementation of Daily Kaizen meetings supported by the framework, it was possible to organize people and enhance teamwork

In the second phase was worked the organization of spaces, using the 5S (see Figure 4) and Visual Management, it began with the selection of tools that are currently used, storing obsolete or unserviceable parts. Then set up a practical and logical layout, for stowing parts, putting whenever possible sets of grouped pieces, with the heaviest pieces were arranged on the chest, while the lighter were stowed in more difficult access locations. After defining the layout, the initial conditions were reset, using the cleaning and inspection of each tool, in order to verify that maintenance would be required. The next step normalized if the above three steps by marking and assigning a physical place for each tool and create standards of housekeeping and cleaning equipment. Finally and in order to ensure that conditions remain, operators were formed in the rules created.

Figure 4 - 5S Implementation

The implementation of the second phase of Daily Kaizen with an example of the implementation of 5S presented on Figure 4 brings benefits not only to the organization as internal customers and suppliers. The natural team is benefited because it has better organization of the workplace, more security, more motivation. The job of the team leader is facilitated because the organization of the workplace facilitates the management of people and materials in the area.

With the implementation of Daily Kaizen teams could provide the means to develop continuous improvement autonomously, thus analyzing the problems of day-to-day and looking for solutions and suggestions for themselves, aiming to reduce variability and to normalize all the process area.

Phase 2: SMED:

As described in the section 2.3, the SMED methodology developed by Shingeo Shingo is divided in five main steps implemented in Empresa X and described below:

In the first stage it was identified the external and internal work in order to analyze what tasks have to be performed with the machine running it was concluded that there were plenty of external tasks performed with the machine stopped and therefore there were some improvement opportunities.

Then in the second stage it was separated the external tasks of the internal, developing a new working methodology that allows those tasks to be performed with the equipment running so they were performed at the beginning or end of the changeover.

In the third stage the concern was to transform internal work in external work, assigning external and preparation of change to the logistics operator tasks to ensure that operators do not fall away from the machine and this would be the shortest time possible stopped.

At a later stage passed to the reduction of the internal work, through technical and visual improvements that allow the reduction of the duration of internal tasks for such support cars were created in order to facilitate the changeover operations and cleaning tasks it was also created a database of support for the adjustments to be held during the reference changeovers.

Two examples are presented in Figure 5 to reduce internal work through the use of visual management

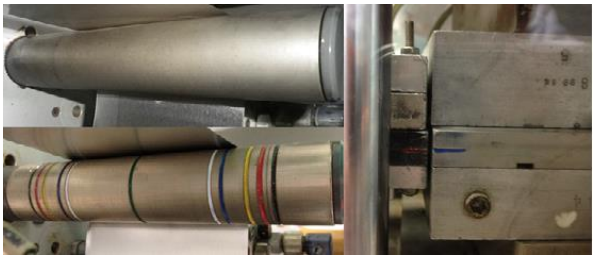


Figure 5 - Internal Work Reduction

In the example on the left, it was improved the placement of aluminum rollers for printing, initially (top left image), the rolls were placed in the printer stand and then were proceeded to adjust the placement trying to be centered, generating waste of time and material.

With the use of Visual Management, defined as the point where it must match the center and the ends of the rollers and was marked using different colors (one for each type of roll) so it is possible to achieve without error and without waste placement indicated the rolls.

In the right example, it is possible to observe the setting of the heating plates of the machine. As the rollers were initially placed and then try and generate waste, resorted to his pitch. With the use of Visual Management, simply hit the two brands and it is not necessary to use more pitches.

Finally, the fifth step, it was proceeded to the reduction of external work, using the simplification of tasks and preparation of change of the task after the machine setup through the creation of a support car, the organization of space and the creation of reference states.

Figure 6 - Reduction of external work

In order to reduce the external work it was created a cleaning the car shown in Figure 6, which includes all cleaning materials needed to clean parts and the machine before and after the changes was created.

Before the car is designed, cleaning materials were stored in a closet-and when they were needed were transported in a car with trays, as can be seen in the left part of Figure 6.

When it adopted the use of car cleaning (of right side) greatly simplified: the task, the material started to be always present in the car, whose design allows the separation of the material and quick and accurate cutting of rolls of cloth and paper. The fact that the car is relatively narrow as can be seen in Figure 6 allows it to be transported to any location in the packing area.

The results obtained were very positive, with the simplification of tasks, reducing the time for change and partial elimination of error.

Phase 3: Maximizing the yield in the packaging:

In the final step of the implementation phase, improvements that would allow maximizing yield in the area of packaging were identified. Thus normalized the work to be performed by logistics operators, enabling the active participation of the same in the reference changeover and ensuring that these same operators were doing their job on time and on terms.

There were also identified consumables rupture problems, in order to solve this the Kanban system was implemented for these same materials to ensure that will be no shortage in the future.

The results were positive with the replacement of materials proved to be timely and in adequate amounts.

5 Follow-Up

Aiming to be updated and consulted daily, a control room, in which were placed various elements of follow-up work, including graphical monitoring of KPIs, audits by area, schedules of workshops and an action plan for solving problems.

One of the key points developed to ensure the control and monitoring of the work monitoring meetings are held fortnightly. With these changes is to ensure that a culture of continuous change, still being cultivated by the leaders of the various departments in order QCDM growth.In order to measure the benefits the KPI's defined above were controlled after the implementation phase.

After the description of the control of the work plan, the benefits generated in the Industrial area of Empresa X were evaluated and are presented in Table 2:

Table 2 - Measuring KPI's Benefit

QC DM	KPI	Base	Annual Goal	Final
C	OEE	44%	≥ 55%	54%
C	Productivity (U/FTE)	385.682	≥482.103	432.036
C	Unit Cost	1,16€	≤ 0,99€	1,02 €
D	*PCT*	64,3 d	≤ 58 d	41d
C	ACT	04:14:29	02:00:00	02:14:20

As can be seen in Table 2 there was a very positive development in key performance indicators monitored, resulting in a general approximation of the state reached with the goals set before the implementation phase.

Analyzing individually, there were significant improvements in OEE indicator with an increase of 23% compared to the beginning of implementation.

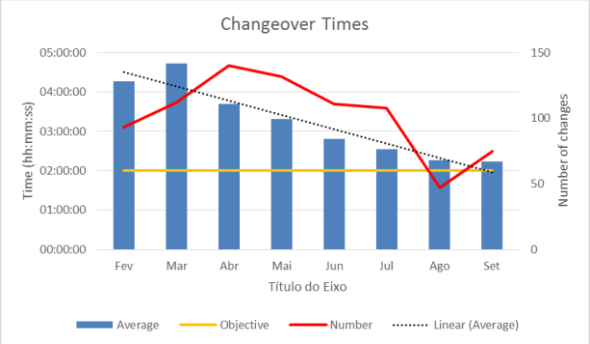
In terms of productivity, there was an increase of 12% continuing to provide this indicator quite short of expectations.

Regarding the indicator unit cost, there was a reduction of € 0.14 per unit which represents a decrease of 12% on the cost.

Looking at the PCT indicator we can verify that it is the only indicator that is within the goal, a reduction of 34% in the time of production.

Finally, the indicator monitoring the average changeover time has a reduction of 47% which makes him the window with larger benefits although this is still a little short of goal.

Due to all the work done to reduce the scope of the ACT will consider the results obtained for this indicator in more detail in the Figure 7:



How is it possible to analyze the trend in Figure 6 the ACT is clearly downward, revealing quite successful in implementing the SMED.

As can be seen in the first month of implementation, there was an increase in the average time of the changes due to the creation of a new methodology for change that in the beginning, to be a novelty, caused a little entropy in routine work, it was necessary to train the new habit to replace the old one.

However, after a month of training, operators revealed faster changeovers, constantly improving the average times in the following months. The goals are not yet fully consolidated, but it is expected that the final value of ACT come near enough goal

Finishing the follow-up phase of this paper will now present the general conclusions.

6 Conclusions

In this paper was presented the implementation of Kaizen methodologies related to the identification of problems of a team spirit, incipient organization of spaces, extended changeover times and a lack of internal flow within the factory.

In order to solve those issues it was held a stage of data collection and analysis in which they were defined KPIs to monitor, its current state, the impact of each on the growth of Empresa X and the goals for each one.

Throughout this phase was possible to determine and plan several actions to improve throughout the industrial area of Empresa X.

The improvements that were planned under this paper are related to the monitoring of the project and the Packaging area, these are directly related to operational efficiency.

It was planned to implement the Daily Kaizen, followed by SMED and the maximum yield of the area of packaging through Standard Work and Kanban

At the stage of evaluation of the benefits results in KPI's industrial area were evaluated. It is possible to detect improvements in most indicators, with the Global OEE with an increase of 23%, the direct and indirect costs with a 12% reduction, Quality Cycle Time with a reduction of 25% Plant Cycle Time with a reduction of 34%..

We also analyzed the benefits of the work done in the area of packaging in which it was possible to decrease by about 47% in average time of change and a 50% increase in efficiency (OEE) of the area, which allies contributed to an increase of about 17% in the overall productivity of the area.

7 References

Almomani, M.A., Aladeemyb, M., Abdelhadic, A., Mumani, A. (2013). A proposed approach for setup time reduction through integrating conventional SMED method with multiple criteria decision-making techniques. Computers & Industrial Engineering Volume 66, Issue 2, October 2013, 461–469.

Bonaccorsi, A., Carmignani, G., Zammori, F. (2011) Service Value Stream Management (SVSM): Developing Lean Thinking in the Service Industry, Journal of Service Science and Management, 4, 2011, 428-439

Cardinal, L. B. (2001). Technological Innovation in the Pharmaceutical Industry: The Use of Organizational Control in Managing Research and Development. Organization Science, Volume 12 Issue 1, January-February 2001, 19-36.

Chera, B. S., Jackson, M., Mazur, L. M., Adams, R., Chang, S., Deschesne, K., Marks, L. B. (2012). Improving quality of patient care by improving daily practice in radiation oncology. Seminars in radiation oncology, 22(1), 2012, 77–85.

Chen, J.C., Cheng, C.H., Huang, P.B. (2013). Supply chain management with lean production and RFID application: A case study. Expert Systems with Applications, 40, 2013, 3389–3397.

Cusumano, M.A., The Japanese automobile industry, Cambridge: The Council on East Asian Studies, Harvard University, 1989, 262-319.

Dotoli M, Fanti, M.P. Rotunno, G. Ukovich, W (2011). A Lean Manufacturing Procedure using Value Stream Mapping and the Analytic Hierarchy Process. In: Proceedings of the 2011 IEEE Conference on Systems, Man and Cybernetics (IEEESMC 2011). Anchorage, USA, October 9-12, 2011.

Ferradas, P.G.; Salonitis, K. (2013). Improving Changeover Time: A Tailored SMED Approach for Welding Cells. Procedia CIRP vol. 7, 2013, 598-603.

Imai, M. (2012). Gemba Kaizen. McGraw-Hill, 2012.

Jimmerson, C., Weber, D., e Sobek, D. K. (2005). Reducing waste and errors: piloting lean principles at

Intermountain Healthcare. Joint Commission Journal on Quality and Patient Safety, 31(5), 2005, 249-257.

Kaizen Institute. (2014). Kaizen Institute Internal Documentation.

Mano, Y., Akoten, J. Yoshino, Y. and Sonobe ,T. (2013), Teaching KAIZEN to small business owners: An experiment in a metalworking cluster in Nairobi. Journal of the Japanese and International Economies.

Murata, K., & Katayama, H. (2010). Development of Kaizen case-base for effective technology transfer–a case of visual management technology. International Journal of Production Research, 48(16), 2010, 4901–4917.

Ohno, T. (1982). How the Toyota production system was created, Japanese Economic Studies 10 (4), 1982, 83–101.

Ortiz, C. (2010). Kaizen vs. Lean: Distinct but related. Metal Finishing, 108(1), 2010, 50–51. Pampanelli, A.B, Found, P., Bernardes, A.M. (2013). A Lean & Green Model for a production cell. Journal of Cleaner Production. Available online 20 June 2013.

Shah, R., e Ward, P. T. (2003). Lean manufacturing: context, practice bundles, and performance. Journal of Operations Management, 21(2), 2003, 129-149.

Shingo, S (1985a). A revolution in Manufacturing: The SMED System. Stamford, CT: Productivity Press

Teichgräber, U. K., e de Bucourt, M. (2012). Applying value stream mapping techniques to eliminate non-value-added waste for the procurement of endovascular stents. European journal of radiology, 81(1), 2012, 47–52.

Tenera, A., Pinto, L.C. (2014). A Lean Six Sigma (LSS) project management improvement model. Procedia - Social and Behavioral Sciences, 119, 2014,) 912 – 920.

Shingo, S (1985a). A revolution in Manufacturing: The SMED System. Stamford, CT: Productivity Press.

Warnecke, H.J., Hüser, M. (1995). Lean production. International Journal of Production Economics Volume 41, Issues 1–3, October 1995, Pages 37–43.

Womack, J.P. and Jones, D.T., (1996), Lean Thinking: Banish Waste and Create Wealth in our Corporation (Simon e Schuster, New York, USA).