Application of Lean Manufacturing Principles in a Food Industry Company (II)

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November 2017

Abstract

In today's world, the competitiveness demanded by global markets and consumers forces companies to constantly improve in order to be able to adapt quickly and efficiently to new challenges, under the risk of not surviving.

Based on this current situation, companies are forced to adopt policies related to improvement. From this perspective, Lean principles that uses a set of methodologies and tools to guide processes and people to eliminate waste and create value. This dissertation aims to study a practical case, develop a diagnosis and implement and develop improvement solutions based on Lean tools.

The case study was carried out in the industrial unit one of a food company, more specifically in the production line four (LP4), responsible for the production of pies. The dissertation begins with a small literature review of the study area in question. The diagnostic phase for production line four is followed by the study of methods, times and the company registration tool. This diagnosis was made according to the method & times study, the Overall Equipment Effectiveness of the LP4 and the operational costs specifically waste and overweight. This is followed by a phase dedicated to the analysis of the diagnosis where the limitations of the productive system and its sources of waste are identified. Based on diagnostic analysis, integrated improvement solutions such as 5S, Kanban method and punctual improvements are developed.

Many of the proposed solutions were implemented, mainly those that are dedicated to the stabilization of the productive process and developed solutions that will make the company more efficient, flexible and with less waste, enabling the production of products with higher added value.

Keywords: Lean Manufacturing, Overall Equipment Effectiveness, Method Engineering, 5S, Kanban.

1. Introduction

In today's economic world, companies can only survive if they achieve sustained profit margins. However, in the market economy, which corresponds to the current situation, gaining more selling more is difficult due to the high competition that is currently observed. Over the years various theories and tools have been developed so that each company can deliver products that perfectly match customers' expectations, at substantially reduced costs and with a quality of excellence. It is in this sense that continuous improvement arises - a long-term strategy. [1]

The present study intends, through the application of "Lean Thinking" and its tools, to contribute to make the productive system of the industrial unit more flexible, efficient and competitive, with LP4 being the object of application / study.

2. Importance of Production Management

Nowadays continuous improvement is in the heart of any company's strategy, largely due the evolution of the economic conditions.

According to Courtois *et. al.* (2006), it is possible to distinguish three stages of evolution of production management within companies.

The first phase represents a period of sharp growth, with the market allowing comfortable margins and a supply of goods below demand. At this stage everything that is produced was sold.

Once balanced the demand and supply, we reached a second stage where the customer can choose their supplier. It was about producing what could be sold.

Very fast in a more recent phase, our current era, surplus supply generates ruthless competition between companies. According to Courtois *et. al.,* 2006, this competitiveness forces the company to [1] [2]:

• Optimization of costs;
• An impeccable quality;
• Short and respected delivery times;
• Small customized production series;
• A renewal of products whose life span has become shorter;
• Adaptability to the evolution of product design and manufacturing techniques

The great challenge of this century is to adopt continuous improvement strategies in the company in the long run in order to achieve sustained growth and success, abdicating the search for short-term strategies that only present immediate and tangible results - the so-called “quick wins” [1]

3. Lean Manufacturing

Lean Manufacturing is a process-oriented system, based in the implementation of a set of tools in order to identify and reduce waste. The waste reduction is crucial to the Lean philosophy. Seven types of waste were identified: overproduction, inventory, waits, transportation, excessive movements, defects, reprocessing. Womack and Jones also identified an eighth waste, which is related to the people's underutilization, specifically their ideas and creativity (Womack and Jones, 1996). [3] [4]

3.1. Lean Thinking

In 1996, Womack and Jones wrote a book with the purpose of publishing a cross-action guide to all industries. The principles of Lean thinking are simplified into five main steps [4] [5]

- Set Value;
- Set value stream;
- Set continuous flow;
- Synchronize production with demand;
- 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 all the workers for the continuous improvement.

3.2. Lean Tools

In this study, some of lean techniques and methods were applied such as PDCA, OEE, 5Whys approach, Kanban system and 5s.

3.3. PDCA

Within all theories and tools the focus of an improvement program should be on the way it is oriented, namely in defining objectives and methods in solving a given problem. [6]
PDCA is an improvement methodology based on the scientific method of proposing a change in a process, implementing change, measuring results, and taking appropriate action. The PDCA name is an acronym for the initials of the 4-step method: [7] [8]

• Plan - Problem should be objectively defined and the situation investigated by performing the 5W analysis to identify the root causes
• Do - At this stage an action plan based on the information gathered in the previous step should be developed and implemented
• Check - This step evaluates the improvements made in the previous step.
• Act – This step links the process improvement and process stabilization.

3.4. 5Whys

The 5 Whys method is a process that consists of asking "Why?" successively until a possible root cause is found. The number of times the question should be asked depends on the case and the complexity of the problem. [9]

3.5. Pareto Diagram

A Pareto chart, also called a Pareto distribution diagram, is a vertical bar graph in which values are plotted in decreasing order of relative frequency. Pareto charts are extremely useful for analyzing what problems need attention first because the taller bars on the chart, which represent frequency, clearly illustrate which variables have the greatest cumulative effect on a given system. [10]

3.6. OEE

Overall efficiency or OEE (Overall equipment efficiency) measures the overall performance of a process or system. This tool allows the user to measure and analyze the performance of a productive process through a detailed analysis of its efficiency. It is evaluated according to three elements involved in value creation: availability, performance and quality. [11]

3.7. 5´S

The 5S consists of a methodology that includes five steps. They are characterized by a Japanese word beginning with the letter S: Sieri (Organization), Seiton (Housekeeping), Seiso (Cleaning), Seiketsu (Standardizing) and Shitsuke (Self- discipline). The first step is the removal of all unnecessary tools and materials to further productive activity. Then it proceeds to the materials and tools storage which are in fact considered essential to the productive activity. The third step is to clean the workplace. The next activity is necessary to teach employees the rules and operative tasks. Thus, operators are able to identify anomalies. Finally, it is important to ensure that the rules and the implemented standards are being met by all operators. [12] [13]

3.8. Kanban

Kanban is a system designed to control both inventory levels. It's also a powerful tool to regulate the production and raw material supply. This technique relies on the principle, that it must be produced only what is requested by the client. [1] [14]

4. Case Study and Methodology

This study aims to use Lean Manufacturing concepts and tools to characterize a production line of a food industry with the purpose of boosting its performance and, consequently, making it more competitive.

4.1. Methodology

The methodology adopted in this study uses the four phases of a PDCA cycle, which was the cycle that guided the improvement program within the company (Figure 1).

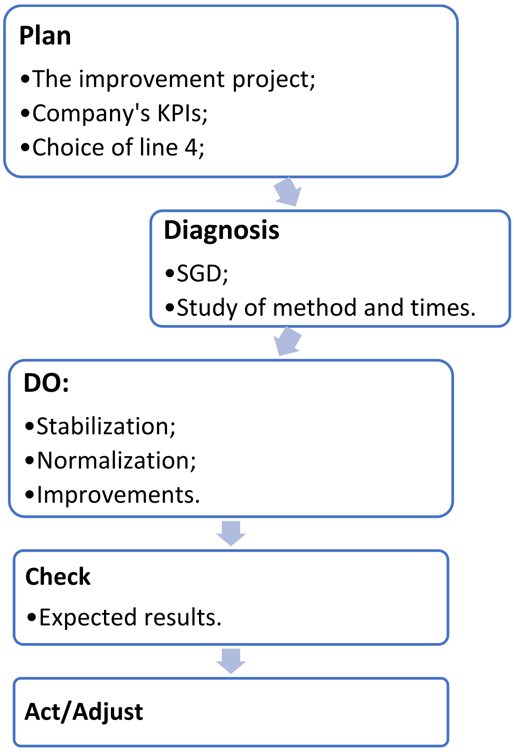

Figure 1 - Methodology adopted in the present study

4.1.1. Company's KPIs - SGD

The Key Performance Indicators (KPIs) used in the company were grouped and documented in a computer tool, the SGD. These records are subsequently entered into the SGD database, allowing the calculation of the OEE, overweight and waste of each production line per shift.

Through the SGD it was possible to better describe the diagnostic phase and evaluate if the improvements implemented in the production process were taking effect.

4.1.2. Study methods

In this study several analytical techniques were used that contributed to a better understanding of the productive process and a qualitative analysis of both the operations and the procedures in each sector of the production line. Two techniques of study of the methods were applied: Visual analysis and Informal Interviews. [15]

4.1.3. Study times

The study of the times is extremely important because it allows obtaining the performance or efficiency of the system through the analysis of the productive and nonproductive times. The qualitative analysis of the production line was made based on the SGD tool (Document management system) of the company and supported in two techniques of study of the times: the timings and the instantaneous observations. [15]

5. PDCA – Plan Phase

Why production line number four

LP4 is the one that presents greater opportunities of improvement since it presents percentages of waste and overweight very high in relation to the kilograms of product that it produces. On the other hand, OEE is under the objectives defined by the company and, unlike the other lines, this is a production line with an increasing volume of production.

Layout Production line 4

Main processes in production line 4 can be summarized in the following macro view (Figure 2):

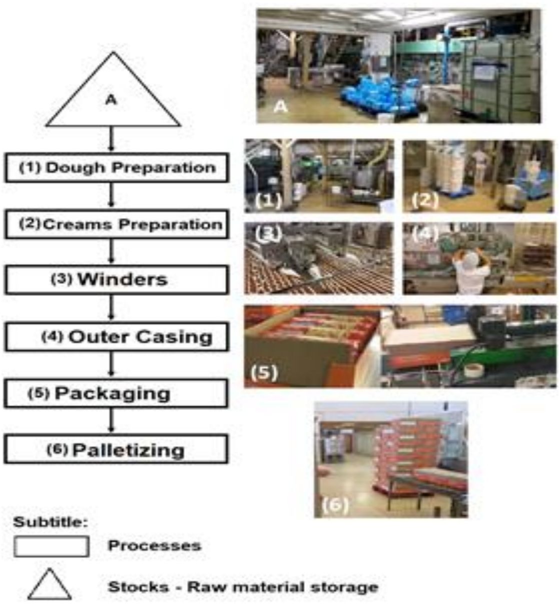

Figure 2 - Main processes in the production line 4

A careful analysis was made for the current state of the LP4 to diagnose less positive aspects in its production process, presenting later valid solutions. Whenever possible, the impacts of these solutions were presented.

5.1. Diagnostic

The diagnostic period of study lasted six months of work in the LP4, and the calculations are intended to simulate the production during this period.

The use of OEE in the diagnostics allowed the understanding of the root causes of the non-productive time and evaluates the current performance of the LP4 with its maximum potential, something especially important and useful in identifying possibilities of improvement of process performance.

The summary of the diagnostic can be seen in Table 1.

Table 1 – Summary of the diagnostic based in OEE

Time calendar (hours)	**4344 h**
Losses due to unallocated time	-1915 h
Losses due to unplanned time	-1392 h
Planned time (hours)	**1037 h**
Losses in Setups	-121 h
Losses in Breakdowns	-94 h
Losses in process manufacturing	-82 h
Theoretical production time (hours)	**740 h**
Losses in micro-stops	-97 h
Current production time (hours)	**643 h**
Losses production waste	-49 h
Time to production good product (hours)	**594 h**
% Availability	**71.36 %**
% Performance	**86.89 %**
% Quality	**92.38 %**
OEE	**57.28**

5.2. Results analysis

Losses in Setups

The losses during the setup phase are the ones that contribute the most to the OEE (12% of OEE). There are two important sources of waste one related with LP4 cleaning and other related with lack of raw materials during production line start-up.

Using the 5whys tool it's possible to know the root causes of these two problems (Figure 3):

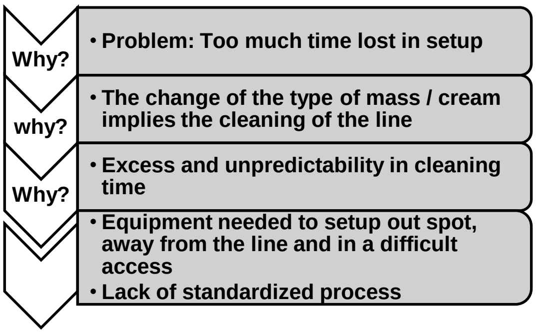

Figure 3 - Schematization of the tool "5 whys" to provide root causes of problems inherent to excessive time in the Setup

Losses in Breakdowns

From the analysis of the collected data it was possible to identify and quantify the failure time by sector, being presented in the Pareto diagram below (Figure 4):

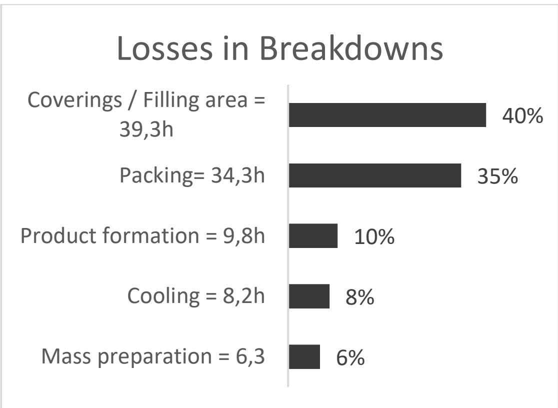

Figure 4 - Pareto diagram concerning losses related to breakdowns

In this way, and given the intense operation to which many of the equipment of the factory were subject and the high price of it, it is suggested the use of a preventive maintenance that avoids damages and returns to the previously used equipment.

Although it is suggested to change the maintenance practiced in this plant, its planning was not part of this work.

Losses in process manufacturing

From the SGD tool it was possible to identify and quantify the main problems related with process manufacturing presented in the Pareto diagram below (Figure 5):

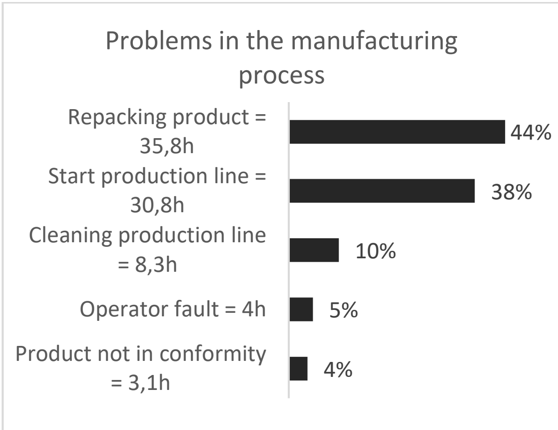

Figure 5 - Pareto diagram concerning the problems related to the manufacturing process

Using the "5whys" tool it's possible to know the root causes of these two problems, for the Repacking product (Figure 6):

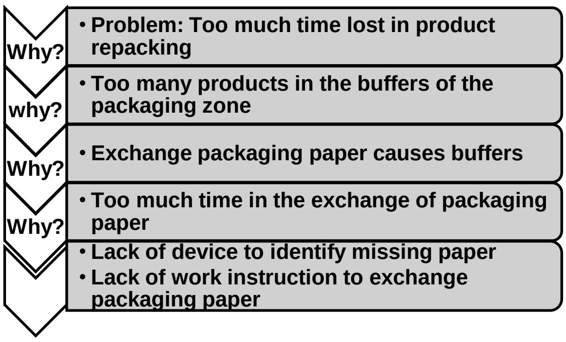

Figure 6 - Schematization of the "5 whys" tool to provide root causes of problems inherent to excessive time in product repacking

And for the problem related to the start of LP4 (Figure 7):

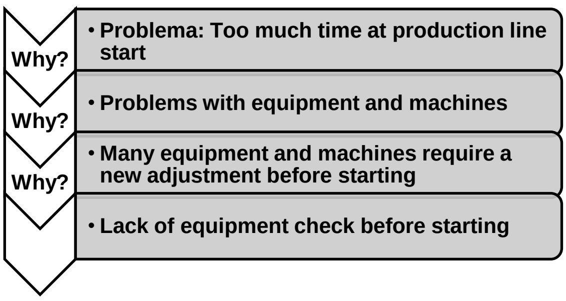

Figure 7 - Schematization of the tool "5 whys" to provide root causes of problems inherent to the excessive time at the start of the production line

Losses in micro-stops

Micro-stop losses represent the gap between the number of units that the production line should produce with its nominal operation and the number of units that actually produces. These time losses were not well defined in the SGD tool, being necessary, through the use of some tools that are part of the study of methods and times, to survey and quantify the origin of these stops.

It is possible to affirm that the losses were associated to:

- Losses resulting from auxiliary tasks - exchange packaging paper;
- Breaks made by the employees;
- Other causes not registered.

Losses in production waste

The time the LP4 is producing waste can be analyzed in two distinct categories, the time wasted in producing overweight (sold to the customer), and time wasted producing non-compliant product, ie product with a weight or waste deficit (not sold to the customer, Table 2).

Table 2 - Percentage of overweight and waste of line four during diagnosis

Month	1	2	3	4	5	6	$\bar{x}$
% O.weight	5,9	6,2	6,1	6,4	4,8	5,5	**5,8**
% Waste	13,1	10,1	9,8	8,6	7,6	7,4	**9,4**

1. Overweight and Underweight

We can indicate three main problems for overweight/ underweight in the weight along the production line and give three root causes for them:

1. Variation of the weight of the dough due to the oscillations of the screen - Change position of cutting blades
2. Variable dough density - No standards in dough production and variability in air machine
3. Variable volume of deposited dough - Lack of work instructions to regulate the depositor bolts

2. Waste

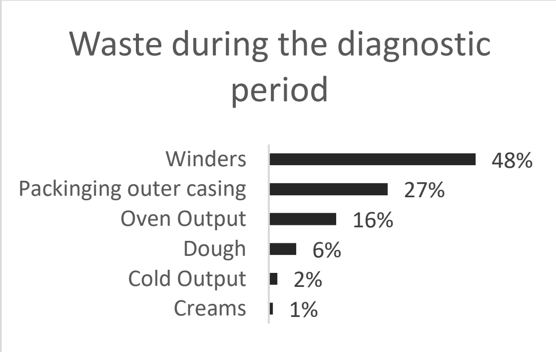

Figure 8 - Pareto diagram concerning losses related to waste

In Figure 8 is presented the percentage of waste produced during the diagnostic period.

Winders and packing areas are areas of the LP4 with many opportunities for improvement, and the search for solutions is essential.

Variability of the process:

There is a large variation in the main performance indicators of the LP4 especially in overweight and waste, reflecting the variability in the line. This variability arises from deviations from the standard. For all processes a standard (or standard) is established. Compliance with the standards must be fulfilled during production until it is questioned by the improvement process and replaced by an improved.

By complying with the production standards, it is possible to reduce the variability and complexity in their execution, since it ensures that all tasks are performed in the same way and in the best feasible way.

The stabilization of the process is one of the bases of the continuous improvement being essential the development of solutions to make the line as stable as possible.

6. PDCA – Do Phase (Solutions)

In accordance with the diagnosis, it is necessary to apply methods and solutions to solve the identified problems in the LP4.

1. Stabilization

The first step was the stabilization of the production line. Stabilization is a key step in a continuous improvement program. Without the stabilization of the productive process, of the various equipment that composes it and the involvement of the various people that constitute it, there is no improvement.

Human Resources

Initial stages of the improvement program to encourage people to intervene and to participate in change. Within the company the mobilization of employees was an essential step to ensure the follow-up of some improvement actions that started in the LP4 guaranteeing the sustainability of positive results, proximity, transparency and a commitment among all.

Processes

For the stabilization of the productive process, it was important to implement the 5S tool. This type of improvement not only improves the visual management of processes and the mentality of all employees, but also significantly improve several problems found in the diagnosis of this dissertation.

Equipment

The equipment is one of the great drivers of the great variability in the weight of each pie. In the LP4 there is equipment capable of being adjusted manually by the employees, being adjusted without any references or standards. This type of procedure, based on trial and error, tends to increase the raw material waste and the variability in the weight of each pie, due to the constant adjustments that were made until obtaining the correct weight in the pie close to the one established by the standards of quality.

Solutions have been found to reduce the variability in the weight of the final product with the decrease of the adjustments by the employees, and at the same time guarantee a stabilization of the whole productive process.

2. Normalization

Gemba Walks is a very useful tool for identifying some problems in the production line as well as monitoring many of the corrective actions and improvement.

The regular practice of *gemba* walks during the internship period made it possible to identify potential sources of waste in the production process. This attitude of going to the spot, watch and understanding, which the Japanese call *genchi genbutsu* (Japanese expression meaning "go and see for yourself") is one of the fundamental elements of the Lean philosophy, being essential for monitoring improvement actions that were or could be developed in LP4.

3. Proposals of Improvement:

Kanban System

The introduction of a Kanban system was a type of solution developed, but not applied, to end problems related to lack of raw material in the production line, making it more flexible by withdraw the obligation of weighing at the beginning of the productive day for the three shifts.

The entire kanban system has been developed for the LP4 (Figure 9 and 10):

Distribution route

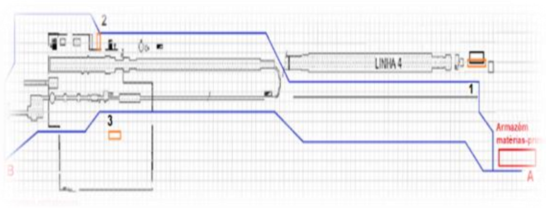

Figure 9 – Distribution Route for kanban system

Necessary equipment like:

- Buckets and tools for repacking raw material;
- Supermarkets in dough, creams and packaging areas;
- Logistics train for carriage of raw materials
- Strips along the production line to mark supermarkets and route;
- Address system

Kanban card

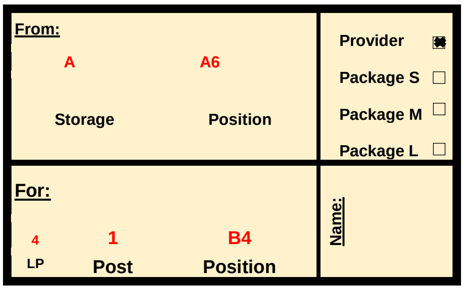

Figure 10 – Kanban card created

Changing the position of the cutting blades

In order to control the problems related to the variation of the weight of the dough due to the oscillations of the screen that caused overweight in certain pies, a change was proposed for the actual cutting system (Figure 11)

Figure 11 - Real image of the improvement implemented in dough cutting

With the inclusion of the two cuts of the dough at the exit of the oven allowed to reduce significantly the variability of the weight of the mass and consequently reduce the waste of raw material.

Identifier for packing paper

In order to solve many of the problems that the exchange of packing paper induce in the productive line, the purchase of an identifier was suggested. This identifier would send alerts to the collaborators in order to inform them of the necessity of exchanging this type of paper.

This solution despite being developed was not applied on LP4 (Figure 12).

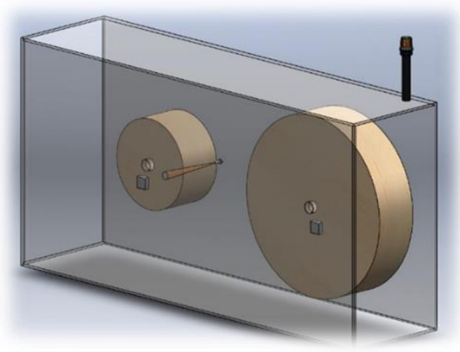

Figure 12 – Implementation of identifier for packing paper.

Check list for startup

Many of the problems caused during the start-up phase occurred due to the poor adjustment made by some equipments or machines, which did not allow normal line operations. It was then suggested a start-up checklist that would allow the correct operation of all equipment and machines to be checked during the start-up phase prior to the supply of raw material to the line.

7. PDCA – **Check Phase (Results)**

For the solutions applied in the production line it’s possible to estimate the following overall results

- Lower variability and greater line flexibility
- Encouraging change;
- Reduction of the values of %overweight and %waste;
- Better transparency in the process;
- Greater organization and hygiene of the workplace;
- Follow-up of actions to improve and control the production process.

In general, the company's KPIs increased significantly and the process variability showed in the KPIs) were reduced (Table 3).

Table 3 – Mean values of the main KPIs in the diagnostic period (a) and after the application of the solutions (b)

	a	B	Improv
OEE	57,33	59,24	**+ 1,91**
% O.Weight	5,82	4,14	**- 1,68**
% Waste	9,43	8,08	**- 1,35**

We can also estimate results for the improvements that were developed but not applied (Table 4):

Table 4 - Solutions developed and its impact on the production line 4

Proposed solution	**Estimated Results**
Check list for startup	1.52% increase in OEE through the reduction 50% of line start-up losses
Identifier for packing paper	Increase of 2.61% and 4.675% of the OEE through elimination of the product repackaging losses and micro-stops, respectively
Kanban system	Estimated increase of 3 to 5% of OEE by eliminating losses related to raw material supply and setup time

8. PDCA – Act/Adjust Phase (Conclusion)

The present study developed in a food company analysis the production line four dedicated to the production of pies based on the Lean philosophy.

The analysed made to the production line four consisted in the development of a diagnosis, the identification of the main problems, the development of proposals for improvement and evaluation of their impact (although in some cases they are no more than predictions).

Through the diagnosis performed in the LP4, were identified limitations that influence the flexibility and the responsiveness to market changes.

Following the analysis carried out, some solutions and improvements were suggested to solve many of the losses found. Some solutions lacked application due to lack of time spent in the company, hence the study of their impacts is difficult to quantify.

The solutions that have been implemented in the stabilization phase allowed the creation of sustained bases with a view to continuous improvement within the company.

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.

9. References

[1] Alain Courtois, Maurice Pillet e Chantal Martins-Bonnefous, Gestão da Produção, 2003;

[2] Euclides A. Coimbra, Kaizen – Uma estratégia de melhoria, crescimento e rentabilidade, 2016;

[3] Michael A Cusumano e Kentaro Nobeoka, “Thinking Beyond Lean”, 1998;

[4] James P. Womack, Daniel T. Jones e Daniel Roos, “The Machine That Changed the World”, 1991;

[5] Bhasin, Sanjay e Peter Burcher, "Lean viewed as a philosophy" In Journal of Manufacturing Technology Management, 2006;

[6] Gustavo Periard, O Ciclo PDCA e a melhoria contínua, 2010;

[7] Chet Marchwinski, John Shook, Lean Lexicon 5th Edition, Lean Enterprise Institute, Inc, 2014.

[8] S.D Bellamy, PDCA – Problem solving guide, 2000;

[9] Uthiyakumar Murugaiah, Samuel Benjamin, Kamaladevi Marathamuthu, “Scrap loss reduction using the 5-whys analysis”, 2009;

[10] Oakland, J. S., Statistical Process Control, Butterworth-Heinemann, Sixth Edition, 2008;

[11] De Ron, A. J., & Rooda, J. E, OEE and equipment effectiveness: an evaluation. International Journal of Production Research, 2006;

[12] Michalska, J., & Szewieczek, D. The 5S methodology as a tool for improving the organization. Journal of Achievements in Materials and Manufacturing Engineering, 24(2), 211–214, 2007;

[13] José Pinto, Modelo de Implementação do pensamento JIT, uma abordagem prática aos conceitos, 2009;

[14] Kumar, C. S., & Panneerselvam, R, Literature review of JIT-KANBAN system. International Journal of Advanced Manufacturing Technology, 32(3–4), 393–408. (2007).

[15] Alexandre Miguel Rocha Novo, Estudo de Métodos e Tempos GESTAMP Portugal, 2008, Relatório do Projeto Final. Faculdade de Engenharia da Universidade do Porto. [Online] Available at: https://repositorio-aberto.up.pt/bitstream/10216/58474/2/Texto%20integral.pdf;