Abstract

Nowadays, the baking industry has a strong market competition, it’s imperative that organizations in this field always look for excellence. The implementation of a manufacturing strategy which focuses on reducing waste during production processes has a huge impact on product quality, equipment availability, environment, and overall productivity. The continuous improvement ensures a higher quality of products and services and a culture that promotes the creation of value.

In this context, the opportunity to develop projects that focus on the reduction of the manufacturing defects and on the increase of efficiency of production in Panrico® facility in Mem Martins has arisen.

The methodology used allowed the identification of the root causes of waste within production processes using Pareto diagram, 5-why-method and Ishikawa diagram, thus restoring the basic conditions and the implementation of measures to improve and optimize it. The results obtained about the waste in cakes production line decreased from 3.5% to 1.6% and the OEE of the bread’s production line increased from 70.5% to 75.1%, where the “unidentified” percentage decreased from 17.7% to 15.5%.

Keywords: Lean thinking, kaizen, continuous improvement, waste, efficiency, OEE.

1. Introduction

In extremely competitive markets, the industry has the need to reduce the time of the production and the overall costs of its process in order to improve the operational performance and the flexibility [1]. Therefore, it is imperative for companies to explore ways to improve their productivity in terms of maintaining safety, using sustainable packaging materials, implementing flexible and standardized technology and adopting proven management principles [2].

The food industry is one of the most competitive market segments [3], so it is essential to ensure a strict control and optimize the production process to aim the waste reduction and delivery times because of the products’ perishable nature [2].

The bakery industry is characterized by a continuous process from the crushed (with a large base flour) to the packaged product. The process begins with the mixing of all the ingredients, forming the dough, which is disposed in molds or trays and taken to a fermentation chamber in which, under controlled humidity and temperature, it increases volume. After that, the product goes into the cooking process carried out in large continuous ovens where it is transported by a metallic conveyor. When the product leaves the oven, it will be cooled in cooling chambers and the all process ends with the packaging [4].

Panrico® is one of the leading companies in the bakery industry in the Iberian market. This company produces bread and cakes, and its commitment is the continuous search for excellence, quality and innovation, it is also set to achieve a larger market segment and to offer the best products to its consumers [5].

The quality becomes one of the main means of competitive struggle [6]. The Total Quality Management (TQM) concept is a management philosophy oriented towards the products/services quality. It is a management area focused on the client needs [7]. Quality management uses a series of tools to improve their operations, of which the Pareto and Ishikawa diagrams stand out.

1) Ishikawa diagram: named in honor of its creator Kaoru Ishikawa, also called “Fishbone” diagram because of its structure. This diagram is an analysis tool, used in brainstorming ideas for problems’ resolution, and it is based in a relation between causes (machine, material, method and manpower – 4M) and an effect (problem, defect, accident or waste form) [8], [9].

2) Pareto diagram: also known as “80/20 rule”, establishes that for many phenomena, 80% of consequences arise from 20% of causes. Starting from this principle, the companies can conduct their efforts into what is truly important [10].

The goal of TQM is to ensure production quality allowing a greater focus on activities that add value [7]. To survive the market competition, the Japanese Masaaki Imai created the Kaizen philosophy which betokens “change for the better” and represents the continuous improvement practice by everybody, every day, and everywhere [11]. Nowadays, kaizen is recognized worldwide as an important pillar of an organization’s long-term competitive strategy [12]. Kaizen is a continuous improvement that is based on certain guiding principles: good processes bring good results; see for yourself to grasp the current situation; speak with data, manage by facts; take action to contain and correct root causes of problems, work as a team; and kaizen is everybody’s business. There are three kinds of kaizen [11]:

1) Daily kaizen – Has as its main goal the development of the working culture, in order to achieve a continuous improvement and attain a constant waste elimination. At its early stage it is necessary to structure and organize natural teams, i.e. teams that work together on a daily basis.

2) Project kaizen – Continuous improvement projects found in early stages of the planning phase. After mapping and finding improvement opportunities, the kaizen project intends to
implement continuous improvements within the structural organization in order to obtain quick winnings, by eliminating waste.

3) Support kaizen – Gathers the top management with the natural team supervisors, and intends to allow that all the problems that have been found are solved and all suggestions taken into account. It is also through this support that a strategy is defined to improve the organization, as well as the collaborators’ training in the tools of continuous improvement [11].

Continuous improvement assumes that collaborators are the best elements for the improvement process, because these groups of people are fully involved in the physical execution of the company’s business processes, confirming that it should be implemented throughout teamwork [13].

Continuous improvement is performed by adding small actions which lead towards perfection, creating a cycle, designated by PDCA cycle (Plan-Do-Check-Act), described by Figure 1 [9].

![PDCA cycle for continuous improvement](image)

In addition to this cycle, there are other methods that allow continuous improvement to become a strong philosophy. As an example, we can consider the 5-why-method (5W’s). This method is a tool used for identifying the causes of a problem, asking five times sequentially, “why” the reason for a given event in order to achieve a conclusion. The number of the questions depends on the size of the problem. Most of the times, three or four times are enough to discover the cause [9].

In summary, the continuous improvement is a philosophy, in which people work as a team to improve the performance of their processes, watching and constantly answering the clients’ needs and expectations [11].

In 1996, Womack and Daniel Jones created the ‘lean thinking’ principle. The lean thinking is an innovative approach to be used in management practices, focused on the gradual elimination of waste, optimizing the results, through simple procedures. The waste is referred to as any activity that does not add value, i.e. activities and improperly used resources, that increase the costs, time, client non satisfaction, or business stakeholders [14].

In terms of operational process, the lean thinking has some fundamental metrics such as Overall Equipment Effectiveness (OEE). The OEE evaluates the overall performance of a process. An OEE is the most influential Key Performance Indicator (KPI) for production management, that measures the gap between the actual performance and the potential performance of a manufacturing unit [15]. The OEE can be expressed by the ratio between production ‘valuable operating time’ and the ‘loading time’ (Eq. (1)), or by the product between availability, performance, and process quality described in Eq. (2) [16].

\[
OEE = \frac{\text{Valuable Operating Time}}{\text{Loading Time}}
\]  
\[OEE = \text{Availability} \times \text{Performance} \times \text{Quality}\]

The ‘availability’ is given by the quotient between the ‘total operating time, described in Eq. (3). The total operating time is

\[
\text{Availability} = \frac{\text{Total Operating Time}}{\text{Loading Time}}
\]

The ‘performance’ is given by the ratio between ‘net operating time’ and the ‘total operating time’ (Eq. (4)), being that the net operating time, is time without quality lost (defective products or waste).

\[
\text{Performance} = \frac{\text{Net Operating Time}}{\text{Total Operating Time}}
\]

The ‘quality’ is given by the ratio between ‘valuable operating time’ and ‘net operating time’ (Eq. (5)), where valuable operating time, is time without any quality lost (defective products or waste).

\[
\text{Quality} = \frac{\text{Valuable Operating Time}}{\text{Net Operating Time}}
\]

The ‘quality’ value can be expressed by the ratio between the ‘number of units produced with quality’ and ‘total units produced’, described in Eq. (6).

\[
\text{Quality} = \frac{\text{Actual Good Units}}{\text{Theoretical Good Units}}
\]

2. Methods

This work applies a method with a set of sequential steps in which lean philosophy is used. The steps of this method are described in Figure 2, performed sequentially in order to achieve the main goals, previously described.

![Implemented methodology diagram](image)

- Integration in natural teams of continuous improvement and selection of projects
- Identification of inefficiencies and their origin
- Restoring basic conditions
- Identification of the causes of inefficiencies
- Application of actions to improve and optimize processes
- Evaluation of results and conclusions
Ishikawa diagram. In addition, improvement actions were applied, in order to eliminate inefficiencies resulting in the problem solution. Finally, the obtained gains were determined; the results were evaluated and the initial goals were compared.

2.1 Treatment of The Collected Data

The data collected by direct observations on the production lines are then downloaded to the computer, in which, using the tools available in Microsoft® Excel, a basic statistical analysis of the data collected becomes possible.

With these data it becomes possible to construct profiles of the frequency of undesirable events, through which it is easy to identify which are most frequent and in what products; at the same time, it is possible to monitor the progress of the data collected before and after some repair work and improvement had been made, in order to provide a continuous improvement of the processes analysed.

2.2 Case Studies

The work focused on the development of two projects on two distinct food lines. The first case study aimed at the waste reduction (defective products) in the cakes’ line on the after oven zone. The aim was to reduce waste by 30%, from 3.5% to 2.5%.

The study object of the second case study was the reduction of speed variations and small stops in the process of the bread’s line, in order to increase overall equipment effectiveness. The target was to reduce the “unidentified” percentage by 30%, from 17.7% to 12.4% and the target areas were set from the line’s beginning to the oven.

Since the emphasis was on these zones, all zones that are not mentioned in each line will not be considered for the purposes of this project, assuming that they do not have direct influence on the stages of packaging and unmoulding in cakes’ line and on the kneading and fermentation stages in the bread’s line.

Thus, in the cakes’ line it was assumed that all variables and parameters relative to the stages before cooking and in the bread’s line after cooking were constant, as the raw materials used and their characteristics, mixing conditions (dough temperature, stirring time), fermentation conditions (duration, temperature and humidity) and cooking conditions (duration, temperature of oven zones burners).

2.2.1 Case study I – Cakes’ line

In cakes’ line two types of products are produced, the product A and the product B. The main difference between the two products is the chocolate cream injection into product A.

After cooking, the products leave the oven and they are demoulded of their trays with a suction and blowing equipment and a demoulding plate. Then, they are conducted to the cooling chambers. After cooling, the products are ready to be packed. In the case of these cakes, the package is divided into two parts: at first an individual package for each individual cake and finally a second package that groups several individuals.

When the cakes leave the cooling chamber they are conducted by carriers and spread over three packaging machines that package each cake individually and in an automatic way.

The individual packaged cakes undergo by one metal detector and by a scale weight that allows reject products with the following occurrences: cakes with weight below the minimum limit (weight rejection); cakes very close to each other (cadence rejection); packaged cakes attached to each other (longitudinal rejection). After that, they are transported to the pack machines by a metallic conveyor, resulting in packages of 2 or 4 units of product A and 8 units of product B. Finally, the cakes are placed by operators inside boxes and they are ready to proceed to the final customer.

Since it is in the packaging process that much of the visual selection of the product occurs, it is in this zone that much of the waste line is focused. So, every detail in this stage has a high importance to help achieve the ultimate goal of reducing waste in the cakes’ line.

2.2.2 Case study II – Bread’s Line

All work was developed using lean thinking, following continuous improvement strategies in monitoring and optimizing the processes in evaluation. In Panrico®, it is considered that efficiency losses in production lines may be due to:

- Waste, all that is wasted along the production line negatively influences the actual amount of product produced;
- Exchange format, non-productive time due to changes (cleaning, preparation of machines) between two consecutive products produced in the same production line;
- Low income, an indicator that has no single definition, which includes occurrences that negatively influence the efficiency of a production line but is not included in the definition of any other indicator;
- Breaks, for instance time for meals;
- Failures, affecting the production efficiency since a production line has to stop until the failures are being repaired.
- The main problem in bread’s line was the high unidentified percentage of the failures, due to small stops and the process speed variation.

3. Results and Discussion

3.1 Case study I – Cakes’ Line

Data of the defects were collected and analysed without ever neglecting the continuous improvement of tools around which this project focuses. According to lean thinking, any changes to be made must be substantiated with evidence from case studies, thus the great importance of data collection and its analysis.

After the collected data, the Pareto diagrams were constructed, identifying the most frequent defects. In the Figure 3, it is shown a Pareto diagram with the frequency of the product A defects (units/h), before all improvement actions.

According to the diagram of the Figure 3, it was verified that the most frequent defects in the product A are a, b, c, and d, representing 76% of the occurrences.

After building the Pareto diagrams for two products of the cakes’ line, it was used the 5-why-method to find possible causes of the defects. After applying this tool, the four M’s were identified according to their origin: “machine, material, method and manpower” and the Ishikawa diagram was built to find out the root causes of the frequent defects.

Before suggesting the improvement actions, the manufacturing processes were analysed, restoring some basic processing conditions. The restoring action with greater impact was on the demoulding plate. This equipment is most suitable for demoulding product B than product A, so it produced a and b defects in the product A.

Figure 3 - Pareto diagram of the frequency of product A defects, before all improvement actions.
As shown by Figure 4, the product A had a reduction of the a and b defects from 34/h and 23/h to 2/h and 3/h, respectively, corresponding to a decrease of 90%.

After restoring all basic conditions in the cakes’ line, the next procedure was to suggest the improvement actions in the process. One of most important actions realized was the replacement of the suction and blowing equipment. This equipment was deforming and scraping the cakes and it produced the g defect. Furthermore, it was disorganizing the cakes in their trays, contributing for a and b defects and leading to a demoulding inefficient.

The Figure 5 illustrates the reduction of the g defect in the products A and B, from 5/h and 4/h to 0.5/h and 0.3/h respectively, corresponding to a decrease of 91%.

The results of the effect of processing in the product A before and after all actions are presented by the Pareto diagram in the Figures 6 and 7.

From the diagrams presented it’s possible to conclude that the defects of product A decreased significantly, corresponding to a decrease of 60% and the balance is very positive. In general, the implemented actions had a positive impact.

At the end of the reduction waste project of the cakes’ line, it was found that the waste decreases from 3.5% to 1.6%, corresponding to a reduction of 46%, exceeding the 30% target.

3.2 Case study II – Bread’s Line

Using the same methodology, it was concluded that the main root causes for the high unidentified percentage were the deficiency of preventive maintenance and limited line structure and technologies. The solution was approached using the lean thinking, defining natural teams (daily kaizen), creating a data collection system and discussing possible actions in weekly meetings.

It was verified that there was a reduction of percentage “unidentified”, from 17.7% to 15.5% (in 13%), leading to an increase of the OEE from 70.5% to 71.5%. The balance was positive.

4. Conclusions

The implementation of three types of kaizen was essential, because data were collected and analysed daily and its results discussed in weekly meetings. In conclusion, it was developed the ‘daily kaizen’, with the involvement and training of employees and the ‘project kaizen’ achieved improvements. Throughout the work, it was also developed ‘support kaizen’, suggesting and discussing ideas and developing a strong continuous improvement culture in the company.

In conclusion, it was possible to identify the root causes in major of the target-problems, using the Pareto and Ishikawa diagrams and the 5-why-method.

In a final step, the obtained gains were determined and the results were evaluated and compared to the objectives of the initial phase. The reduction project had a positive result, having a reduction of 46%, thus exceeding the targets. However, the project to increase OEE did not have such satisfactory results as it had an unidentified percentage of the failures decrease of 12% over the starting value. The Table 1 summarizes the results obtained against the objectives considered. In conclusion, the projects carried out were feasible, however, it would be necessary to invest in certain actions referred before, in order to obtain a faster and favourable return and, consequently, to increase the longevity of the company.
The growth of an organization and the operational excellence achieved by it is based on continuous improvement projects which promote the optimization of processes and products, through the resolution of problems and the implementation of improvement actions. In this way, it is possible to eliminate waste and actions without added value, leading to an enhancement in production efficiency.

References


