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Process Improvement in a Food Production Company

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Master in Management of Services and Technology

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ISCTE Business School

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BUSINESS
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Department of Marketing, Operations and General Management

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RESUMO

Na sociedade moderna, as empresas enfrentam cada vez mais o desafio de lidar com diversos problemas que afetam os resultados de negócio. O mesmo se aplica à Empresa B, que procura criar condições ideais para alcançar os objetivos planeados através da maximização da melhor utilização possível dos recursos. Esta empresa, do setor da indústria alimentar, recorre a diversos meios para minimizar as ineficiências e ineficácias do seu negócio.

Um dos principais objetivos da empresa consiste na redução dos diferentes tipos de desperdícios gerados ao longo dos processos de produção, nomeadamente na produção de bolos redondos, alcançável com a adoção de métodos e práticas específicas. Através de um projeto de investigação de ação, desenvolvido em colaboração ativa e próxima com a organização, esta tese aplica uma variedade de ferramentas lean para obter melhorias no desempenho do processo.

Com a identificação das deficiências no processo de produção, e a análise detalhada das causas subjacentes, foi possível estabelecer propostas de soluções viáveis que atuassem diretamente na origem destes problemas. As principais soluções encontradas envolviam a atualização e organização dos documentos técnicos dos equipamentos (5S), a nova etiquetagem das opções dos equipamentos (Gestão Visual), a instalação de um dispositivo de comunicação na linha de produção, e a criação de instruções de trabalho específicas (Trabalho Padrão). A aplicação destas medidas concretas reduziu o impacto causado pelos problemas na produtividade e desempenho operacional, resultando numa diminuição do desperdício de produto defeituoso, e em ganhos através da redução do tempo gasto em determinadas tarefas do processo.

Palavras-chave: Melhoria dos processos de negócio; Filosofia lean; Produção alimentar; Action research; Ferramentas lean

Classificação JEL: L66 – Alimentos, Bebidas, Cosméticos, Tabaco, Vinho e bebidas espirituosas; M11 – Gestão da Produção

ABSTRACT

In modern society, companies are increasingly facing the challenge of dealing with a variety of problems affecting the business results. The same applies to Company B, which aims to create the ideal conditions to achieve the planned goals by maximising the best possible use of its resources. This company, operating in the food manufacturing sector, makes use of a variety of means to minimise inefficiencies and ineffectiveness in its business.

One of the main purposes of the company is to reduce the different types of waste generated throughout its production processes, namely the round cake manufacturing, achievable with the adoption of specific methods and practices. Through an action research project, developed in active and close collaboration with the organisation, this thesis applies a variety of lean tools to obtain improvements in the process performance.

With the identification of production process deficiencies, and the detailed analysis of the underlying causes, it was possible to establish proposals for viable solutions that would act directly on the source of these problems. The main solutions found involved updating and organising the equipment's technical documents (5S), re-labelling the equipment's options (Visual Management), installing a communication device on the production line, and creating specific work instructions (Standard Work). The application of these concrete measures has reduced the impact caused by the problems in productivity and operational performance, leading to a decrease in wasteful defective product, and gains by reducing the time spent on particular process tasks.

Keywords: Business process improvement; Lean philosophy; Food manufacturing; Action research; Lean tools

JEL Classification: L66 – Food, Beverages, Cosmetics, Tobacco, Wine and Spirits; M11 – Production Management

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1. INTRODUCTION

This introductory chapter aims to facilitate the following and understanding of this project, with a brief and general explanation of several associated topics. In this manner, with the description of the topic and respective research question, as well as the definition of the objectives inherent to this project and the identification of the different phases to be followed to obtain an answer to the question initially presented, it becomes possible to realise the nature of the project and its context. In this section, the project structure is also included, providing an overview of how the work was conducted.

1.1. Problem Statement

In today's business world there is a constant search for effectiveness and efficiency in business processes, as organisations not only seek to achieve the desired results, but also strive to continually refine and innovate their competencies to stand out from the competition (Kock et al., 2008).

As shown by Adesola and Baines (2005), Harmon (2014) and Drohomeretski et al. (2014), for businesses to become more profitable and sustainable, organisations are increasingly looking to invest in improving their processes to be able to achieve more with less, and in this way deal with external changes and market pressures. The idea that business processes improvement is being increasingly sought is also shared by Zellner (2011) and Abreu et al. (2013), emphasising that it is increasingly becoming one of the main priorities of organisations.

This effort to increase process efficiency and effectiveness is in fact the reality of several Portuguese companies from the most distinct industrial sectors, which, as mentioned by Sá et al. (2022), have been increasingly applying different methodologies that aim to improve the efficiency of their operations and thereby achieve better organisational performances.

The same applies to company B, which operates in the food manufacturing sector, and has some of its objectives aligned with the main ones of that industry, which as Lee et al. (2015) state are related to the efficiency and effectiveness of processes.

In this sense, the company B is also aware of the emerging challenges, the high level of global competition and the arrival of new technologies that force a change and adaptation of its practices, and for these reasons and many others, the company continuously seeks to adopt a philosophy that implies the reduction of waste and the improvement of its operational efficiency, in order to ensure its characteristic and recognised productivity and performance (Lee et al., 2015; Kumar & Harms, 2004). In essence, as Gazova et al. (2016) state, the company B aims to *"streamline the operation of the entire organization and to enhance own productivity"* (p. 197).

Some of the problems impacting on the effectiveness and efficiency of the process under study are, respectively, related to the volume of defective product rejected and the amount of time spent on particular tasks, affecting the process performance.

In this way, the aim of this project is to identify the sources of the problems that compromise the efficiency and effectiveness of the company and solve them, in order to reduce several factors that have a significant impact on the company's performance.

This problem is extremely relevant for the company, since several positive aspects are associated with its solution, such as the reduction of production costs, better exploitation of resources and equipment and, at the same time, less time consumed in the process.

Briefly, this project intends to improve the efficiency and effectiveness of a specific production process by reducing waste and associated costs, standardising activities, improving communication between departments (maintenance and production) and simplifying process-related tasks.

In line with the problem identified by the company, it is evident that the objectives of this project are concerned with improving the process in terms of its efficiency and effectiveness. In this regard, the purposes involve mapping the current situation of the process and, based on the detected problems, proposing improvements to be subsequently implemented and evaluated to further increase the efficiency and effectiveness of the process under study.

1.2. Research Question

According to the previous information, it is possible to perceive what will be the research question associated with this project: *"How to improve the effectiveness and efficiency of the process X in company B?"*.

In order to have a better understanding of this issue to achieve the desired answers, as well as to better conduct this research, the main problem is usually divided into sub-problems. In this way, the sub-problems are directly related to the main problem as well as to the research question, these being in this case the following ones:

- How is process X currently performed?
- What are the existing problems affecting the effectiveness and efficiency of process X?
- What are the main root causes of the problems?
- What solutions can be proposed to make process X more efficient and effective?
- What is the impact of the improvement proposals?

1.3. Methodology

Once the objectives of the project and the respective research question have been defined, it becomes important to clarify how exactly it is intended to answer the question and achieve the desired objectives. In this sense, the methodology refers to the action plan to obtain these answers and goals, through the application of specific methods. In addition, the methodology adopted should take into consideration the nature and features of the project.

This project is considered as an in-company project, as it is performed in company B, with the view to develop and implement solutions to improve an existing process. Therefore, considering the nature of this project, as well as its research question and its objectives, both focused on improving and solving a real and practical problem in company B, the most appropriate methodology to be applied is the action research one. A key aspect of this type of methodology is related to its highly participative and collaborative approach, since all participants, including the researcher, are actively involved and deeply integrated in the project and also in the company (Gaspar & Leal, 2020; Saunders et al., 2016).

The action research cycle used in this project is structured according to Saunders et al. (2016) and Coghlan and Brannick (2005), which involves a preliminary step, concerning the context and purposes of the project, followed by four basic and fundamental activities, that correspond to diagnosis, action planning, taking action/implementation and subsequent evaluation. This is the main cycle of action research, but there is another cycle that operates alongside it, the meta learning, which is a reflection cycle described by Coghlan and Brannick (2005) as being *"an action research cycle about the action research cycle"* (p. 25). Nevertheless, since several authors recognised the relevance of introducing a monitoring stage in this process, the meta learning phase is adjusted accordingly. Within this context, the meta-phase is adjusted by combining the reflection proposed by Coghlan and Brannick (2005) with the monitoring proposed by Coughlan and Coghlan (2002), with this phase being applied in a transversal way throughout the project.

Along these lines, through a constant involvement and participation of collaborators and researchers, this methodology with its cycle allows solving the problems introduced by the company and consequently improving the efficiency and effectiveness of the process in question, this being the main objective of the project (Saunders et al., 2016).

1.4. Scope

The company B, on which this thesis is based, is a bakery company operating in the food production sector in Portugal. Due to the diversity of products, the production unit is divided into different production lines according to the product typology. The company showed special interest in having this project focus essentially on one of the lines, and so, depending on the outcome, being able to later replicate in the other production lines some of the project's ideas.

In this sense, the production line under study in this project refers to the manufacturing process of round cakes, this process being designated for the purpose of the project as process X.

This project involves the maintenance department, whose responsibility is to maintain and guarantee the correct functioning of the equipment used in the production process, so as to minimise potential technical faults or breakdowns that affect the production chain, as well as to reduce possible associated costs. Moreover, this department also aims to stimulate a critical thinking by the technicians

to create a culture focused on the continuous improvement of the processes and to act in a pro-active way by focusing on preventive maintenance instead of corrective ones.

An important note is that the organisation's departments work in coordination and collaboration to assure that the results obtained are the best ones possible, as this is always the ultimate goal of the companies. In the current project, the departments involved are mainly the maintenance and production departments, cooperating openly and in line with each other on a daily basis.

1.5. Project Structure

This project is organised and structured into five major chapters, as is common to this type of in-company project. In this sense, the first chapter corresponds to an introductory phase of the project theme and includes the identification of the problem that led to its development, the objectives, the associated research question, and the methodology applied, as well as the project structure.

The second chapter is dedicated to the literature review that covers several concepts relevant to the project, starting with a more general approach on business process change and ending with more specific concepts, including methodologies, tools and application cases of the addressed theoretical contents. In this way, this section provides the theoretical support for the development of this case study with an analysis of other similar studies.

The third chapter refers to the methodology followed in the data collection process and in the processing of the information required to develop the project. In other words, the methodology is concerned with the way in which the project is oriented and conducted.

The fourth chapter concerns the case study of the project and presents a brief contextualisation of the company and the corresponding problem, as well as addresses all the different phases involved in the project. Furthermore, the results and subsequent analysis and discussion are also provided in this section.

The final conclusions of the project development, including the answer to the research question, are described in the fifth chapter, which also incorporates the limitations related to the study, as well as possible future research associated with the topic.

2. LITERATURE REVIEW

In this part of the project the different topics related to this thesis are presented and described, as well as examples of practical application of some of the concepts, in order to support in theoretical terms the present work. In this sense, a systematic literature review was pursued to ensure a correct and structured research process.

The content research was developed through multiple database platforms, including B-on, Emerald, Google Scholar, EBSCO and Scopus, which provided the necessary information for this study. In order to restrict and limit the results achieved, the search on these platforms was conducted according to specific criteria. In this sense, the selected search filters refer to: the type of source of the articles, which in this case includes only academic journals and conference materials; the year of publication of the article, from 2002 to 2022, covering the last 20 years; the language of the article, being only in English; and peer-reviewed articles. Furthermore, it is important to note that this selection process also took into consideration the quality ranking of the journal that published the article. Through the platform SCImago Journal & Country Rank, it was possible to obtain the rankings of the journals under study and then select only those that are in the first two quartiles (Q1 and Q2), which are the ones with the best rankings.

In all of the database platforms, keywords related to the topic of this project were inserted in order to better conduct the research. The most relevant keywords correspond to *"process improvement"* and *"lean thinking"*, which are entirely related to the subject of this project. In addition, the field *"AB Abstract"* was selected to obtain articles that indeed explored the researched concept while excluding those that only presented the keyword written in the document.

Additionally, this literature review is also based on several relevant books related to the subject, which will be used as support throughout the following sections.

2.1. Business Process Change

A successful business very often depends on an organisation's ability to keep up with the emergence of new market trends, as well as the arrival of new technologies. This idea is advocated by Harmon (2014) when stating that, in part, the emergence of new technologies causes the need for changes that enable organisations to maintain their business attractive to customers, as well as gain a competitive advantage over their competitors. As Harmon (2014) argues, these changes are only possible if organisations are committed to a constant search for innovation, as well as a continuous evaluation of how processes are performed to better understand what can be improved or what needs to be different.

In this context, business processes refer to the set of activities that, when coordinated and executed in a specific and pre-defined order, allow the achievement of organisational objectives,

adding value to the business and at the same time satisfying the customers' needs (Chinosi & Trombetta, 2012).

Organisations often apply the concept of Business Process Management (BPM) as a way to manage, analyse and control their different business processes (Harmon, 2014). This approach facilitates process improvement and, at the same time, contributes to the optimisation of the organisational outcomes.

In this way, it is possible to clearly understand the importance of the processes in an organisation. It is therefore crucial to analyse and control the processes on a regular basis in order to identify if there are issues that may affect the organisation's performance and, if so, take appropriate actions to solve them. There is also a need for organisations to continuously adjust their processes to market requirements and current changes, to ensure their positioning in the market and to gain competitive advantages over their competitors.

2.1.1. Business Process Changes Approaches

There are several methods that allow business processes to be aligned with the real needs of the market or the organisation. The method selection depends on the objective of the organisation and the type of business. Harmon (2014) states that these process changes can be achieved through three different methods, namely Automation, Redesign and Process Improvement.

Process Automation

As previously mentioned, automation is one of the methods suggested for making changes at the level of an organisation's processes.

According to Harmon (2014,), process automation is associated with *"the use of computers and software applications"* (p. 23), as tools to support the organisation's employees or to replace them when executing a business activity. Thus, by incorporating technological tools in the main processes that add value to customers and the business, the performance of the respective activities is guaranteed, and the organisation also benefits from their simplification and optimisation. In parallel, it facilitates process control and monitoring, as well as reduces a number of factors that affect the activity's performance, such as human errors and process time, leading to an increase in productivity (Reijers & Mansar, 2005).

Despite the different positive aspects that the introduction of new technologies has in an organisation, there are also some associated disadvantages that must be taken into consideration. In reality, as Reijers and Mansar (2005) indicate, the costs involved in these technologies are considerably high, from their *"purchase, development, implementation, training"* (p. 303) of employees, as well as the maintenance required for their correct operation, which is sometimes an obstacle for companies.

Also, the less a company keeps up with new technologies and developments, the more difficult and costly it will be to later incorporate that knowledge into the business, which in the long run could have benefited the company in a significant cost reduction.

The application of this method can be carried out in multiple ways, using different tools and technologies. The way it will be implemented depends on the organisation's objectives, on the process in question, as well as on the financial capacity to invest. As Harmon (2014) states, the use of software, like ERP and CRM, or advanced workflow systems are examples of possible ways to automate an organisation's processes. Additionally, authors Ng et al. (2021) and Vincent et al. (2020) describe the concept of Robotic Process Automation (RPA), related to Artificial Intelligence, as another example of an innovative and recent approach to process automation.

Process Redesign

One other method of making changes to processes is by redesigning them. In the same line with Harmon (2014) statement, the creation of new processes or the meaningful improvement of existing ones in the organisation constitute the main focus of the concept of process redesign.

In this context, it is important to highlight the difference between two concepts that are frequently mixed up, namely the redesign and the reengineering of processes. Mansar and Reijers (2007) explore this difference and it becomes clear that process reengineering refers to a more radical and expressive change and restructuration in processes with the purpose of significantly improve the processes' performance (Kock et al., 2008). Whereas redesign occurs on a smaller scale and its changes are mostly focused on how the process is organised and executed (Mansar & Reijers, 2007). In accordance with the authors Harmon (2014) and Mansar and Reijers (2007), this last concept is often associated to alterations in the sequence of activities, to changes in the roles assigned to employees in a certain process, as well as to the introduction and subsequent implementation of more automated processes.

There are several positive aspects associated to this method of making changes in processes, which when applied allows organisations to gain a competitive advantage over other players. Along with this, Vanwersch et al. (2016) presents some of the benefits that organisations obtain when adopting this method, which are related to the reduction in process time and costs, as well as to the significant increase in customer satisfaction, as the quality of the processes is improved.

Kock et al. (2008) explores the idea that a process redesign project should not only focus on workflow representations, where the chronological flow of activities in a process is described, but should also take into consideration representations of communication flows related to the process. Besides that, Kock et al. (2008) reinforce the fundamental role that modelling, especially when standardised, plays in process redesign. Hence, modelling and the use of representative flows represent some of the tools used in process redesign projects (Kock et al., 2008).

Process Improvement

Process improvement is also one of the methods presented by Harmon (2014) to change an organisation's business processes. Harmon (2014) states that this solution, by making more incremental, specific and smaller changes, aims to improve existing business processes in organisations.

The concept of process improvement, as claimed by authors Ciancio (2018) and Curatolo et al. (2014), focuses mainly on reducing costs, increasing process efficiency and effectiveness, specifying and identifying value, as well as optimising organisational performance.

The distinction between effectiveness and efficiency is presented simply and clearly by Drucker (2006), by stating that effectiveness is doing the right things, while efficiency is doing things right. In this sense, Drucker (2006) further explores these concepts, explaining that effectiveness is the ability to produce a better result, providing more value or allowing a better outcome to be achieved, while efficiency is related to the capacity to produce an intended result with the least amount of wasted time and resources involved.

Over time, several frameworks related to the process improvement method have been developed, some being more complex than others. As Widodo et al. (2021) presents, the common and similar steps in all these frameworks are essentially five, the initialisation, the selection, the design, the implementation and, lastly, the evaluation. The initialisation stage is the analysis of the current situation, followed by the selection stage, in which the activities to be improved are identified. The design stage centres on the activities selected to be improved, while the implementation stage corresponds to the application of that improvement in the activity. Finally, the evaluation stage involves an analysis to understand if the implemented improvement is being well accepted and well performed, and if necessary, intervene with the appropriate changes (Widodo et al., 2021).

Since the purpose of this project is neither to automate the process in question, nor to implement large-scale improvements (related to the redesign of the process), it is mainly focused on changes to the process through punctual and minor improvements. Therefore, it becomes meaningful to look more thoroughly and deeply at process improvement as the approach to business process change applied to this project.

2.1.2. Methods used within Business Process Improvement Studies

With regard to this method, several approaches and respective tools can be applied in manufacturing and services, often integrating multiple types of approaches in a single project. The selection of the approach to be adopted by the organisation should take into consideration different factors, mainly the purpose defined by the company and the process that will be modified to be further improved.

In this sense, as the authors Ciancio (2018) and Curatolo et al. (2014) show, process improvement can be achieved by applying different approaches, for instance Six-Sigma and Lean. Simulation and optimisation, according to authors Mehdouani et al. (2019) and Vergidis et al. (2012), respectively, correspond to two other possible methods to be adopted to enhance processes in organisations.

Simulation

Simulation is one of the methods widely used for process improvement purposes that, through a detailed analysis of the processes, enables the identification of errors, bottlenecks and existing problems, and by making specific changes, enables improvement of the processes, eliminating those bottlenecks that affect the capacity of an operation (Mehdouani et al., 2019). The application of this methodology allows organisations to *"improve the efficiency and effectiveness of business processes"* (Mehdouani et al., 2019, p. 226). These improvements can be first tested through the analysis of different scenarios, with the implementation of solutions taking place only after testing those scenarios, detecting errors and preventing problems that may occur (Somphanpae & Boonsiri, 2016).

In accordance with Mehdouani et al. (2019), this approach is composed of four phases, the first one being related to the simulation of the as-is model in order to detect possible failures and its impacts, the second one corresponding to a list of different scenarios each with a set of changes, in the third phase a to-be model is presented that is based on the previously defined scenarios, and finally the improved model is executed, which is subsequently evaluated using the obtained simulation results.

Simulation has been widely used in the literature, both for the services and manufacturing sectors (Jahangirian et al., 2010). The following studies are two examples of this application, demonstrating the importance of simulation as a process improvement approach. The first study, as Somphanpae and Boonsiri (2016) show, concerns the application of simulation in the service activities of a restaurant, while the second one, presented by Guzman-Moratto et al. (2022), explores the use of simulation as a way to improve the productivity of a process in the manufacturing industry. The simulation results of both cases confirm the idea that simulation allows obtaining a much more efficient and effective process, which is associated, in the case of the first example (Somphanpae & Boonsiri, 2016), with less costs, resources and waiting times, and in the second case (Guzman-Moratto et al., 2022), with an increase in productivity, both contributing to a better performance of the processes.

Optimisation

Another commonly used method for improving business processes is optimisation, which is applied to identify the optimal solution to a specific problem taking into account certain constraints (Coello Coello, 2006). From this perspective, optimisation focuses on finding the best solution, and not a better

one, among the possible alternatives (Banga et al., 2003). This concept is also explored by Vergidis et al. (2008), defining it as an *"automated improvement of business processes using prespecified quantitative measures of performance (objectives)"* (p. 8). Indeed, process optimisation enables organisations to obtain competitive advantages, as it contributes to the optimisation of organisational performance and efficiency (e.g., by replacing less efficient activities by other activities with maximum efficiency (Radeschütz et al., 2015)), as well as to the reduction of costs and cycle times, both of which often constitute the goals of this methodology (Vergidis et al., 2012). Also, as presented by Grond et al. (2012) and Mukherjee and Ray (2006), there are several optimisation techniques that aim to improve processes, and its selection, as pointed out by Rao (2009), is essentially dependent on the nature the problem's objective, which can be of a single objective or several objective functions (multi-objective).

Similarly to simulation, optimisation has also been applied for process improvement purposes (Vergidis et al., 2012). The following two studies thus aim at illustrating how optimisation can be used for such purpose. Chen et al. (2014) developed a genetic algorithm to solve an optimisation problem aimed at optimising public bus transportation system in Beijing, China. The developed approach allowed to improve operational efficiency and service quality (by reducing delays and turnaround times, and by improving the service level), while also reducing total costs. Another study was developed by Navalertporn and Afzulpurkar (2011), who proposed an optimisation approach in the tile pressing manufacturing industry aiming at maximising different quality features. This approach allowed to increase the production yield from 60% to 97%, consequently improving the performance of the process.

Six Sigma

Six Sigma is one of the most popular approaches to business process improvement. As Harmon (2014) notes, this concept was introduced as *"a set of statistical techniques that managers could use to measure process performance"* (p. 316), and thus understand what could be changed to improve process efficiency. Also, this methodology, according to Bendell (2005), corresponds to a *"strategic approach"* (p. 971), which, through the focus on the reduction of variations in process results, intends to reach excellence, this being one of its philosophical bases, as Fairbanks (2007) states.

In this sense, with the purpose of improving processes, this methodology aims, by reducing *"defects, redundancy and waste in operational processes"* (Fairbanks, 2007, p. 73), to increase efficiency and organisational performance. Therefore, organisations that adopt Six Sigma obtain several benefits and advantages, since its implementation results in a significant improvement in the quality and performance of processes, a notable reduction in costs and times associated to processes, leading to an increase in customer satisfaction (Fairbanks, 2007; Bendell, 2005).

As presented by authors Siha and Saad (2008) and Fairbanks (2007), this methodology, characterised by its standardisation nature in improving processes and solving inefficiencies, usually follows five phases: define, measure, analyse, improve and control, which correspond to the DMAIC cycle. After identifying and quantifying the problem, it is then important to determine the levels of defects as well as to measure the performance. Then, the information obtained is analysed and the source of the problem is identified. Finally, after solving the problem and improving the defect levels, the last phase is carried out, which corresponds to the process control phase, with the objective of guaranteeing the success of the implemented improvements.

Like the other methods discussed, six sigma is also broadly applied in different business areas, with the goal of improving processes (Bendell, 2005). Improta et al. (2020) present the application of six sigma through the DMAIC cycle in the hospital context, in order to reduce the length of stay of patients operated on due to femur fractures. As a result, the femur fracture surgery process was significantly improved, with a decrease in the average preoperative hospital stay from 6.90 to 3.15 days. Another application of six sigma, through the DMAIC cycle, is now presented in the manufacturing sector by Gupta et al. (2018), with the aim of reducing the variability in bead splice process of a tyre manufacturing company in India and thereby reducing the associated waste. This study led to a significant improvement in the process, substantially reducing the defects involved in the process, as well as the costs supported by the company.

Lean

A further approach often used in business process improvement is the lean philosophy. This approach, according to Gupta et al. (2016), encompasses several management practices that, under the philosophy of continuous improvement, aim to eliminate waste and provide more value to the customer with less costs involved, which means doing more with less. In this regard, this methodology relies on the reduction or elimination of all types of waste involved in the processes, enabling organisations to focus on the activities that really add value to the customer (Régis et al., 2019).

According to Gupta et al. (2016), this philosophy is globally recognised and is often adopted in the culture of organisations in both manufacturing and service sectors. Indeed, the following two studies for each one of the mentioned industries support the importance of the lean philosophy in process improvement, which, by eliminating waste, inefficiencies and non-value activities, enhances process performance. The first study, as Improta et al. (2018) demonstrate, is related to the emergency services of the Cardarelli hospital in Naples, which before the lean implementation was characterised by high waiting times and its overcrowding, affecting the patients' satisfaction. With the lean methodology and its tools, the hospital achieved a better performance of the emergency services through the reduction of waste, being in this case related to waiting times, and through the increase

of efficiency in the services provided. As an example for the manufacturing industry, the second study, presented by Sutharsan et al. (2020), illustrates the potential contribution that the adoption of this methodology can bring to the production process of pumps in India. In this study, it was possible to reduce the production lead time by around 1.4 days and also the defect rate from 3% to 1%, contributing to an enhancement in process efficiency.

Given this overview of some of the different methods most commonly used to improve processes, it is possible to understand its main differences. Since the aim of this project is not to optimise the production process, neither to simulate different scenarios, or to focus on the variability of the process in question, it is possible to exclude the application of the respective methods. On the other hand, since this project is mainly focused on efficiency and effectiveness improvements through waste reduction, it becomes evident that the lean philosophy corresponds to the approach most suitable to be used. The lean philosophy is for that reason explored in more detail bellow.

2.2. Lean

2.2.1. Definition and Contextualisation

Lean, one of the well-known methodologies for implementing process improvement, is becoming increasingly popular in the business world. This philosophy, created by Taiichi Ohno and Eiji Toyoda, was developed in Japan by the Toyota Motor Corporation in 1950 as a set of management techniques and practices that define the company's production system (Vamsi & Sharma, 2014). The adoption of this philosophy has enabled the company to significantly improve its performance, through the elimination of several existing wastes in the production process (Vamsi & Sharma, 2014).

In line with the authors Bakke and Johansen (2019) and Fairbanks (2007), this methodology aims to improve processes by reducing waste and inefficiencies that compromise the activities performance. At the same time, the identification and elimination of activities that do not add value to the business enables an increase in process efficiency, a benefit for the organisation (Fairbanks, 2007). According to Bakke and Johansen (2019), the reductions involved in this methodology do not affect the *"quality or on-time delivery"* (p. 375), but instead improve the value delivered to the customer, resulting in an increase in customer satisfaction.

2.2.2. Principles

Five principles are associated with this philosophy that should be taken into consideration, with these being value, value stream, flow, pull, and perfection, as Bakke and Johansen (2019), Curatolo et al. (2014) and Bendell (2005) present. These principles are therefore respectively associated to the definition and identification of the value perceived by the customer, to the flow specification of value

and non-value activities and processes involved in delivering the product to the customer, to the identification and design of a continuous and optimised value stream, to the implementation of systems where production depends on customer demand, and to the continuous search for perfection (Curatolo et al., 2014).

2.2.3. Waste

Considering that this philosophy is concerned with the elimination of all sources of waste in the processes (Bakke & Johansen, 2019), it is important to understand the different types of waste that are defined in this methodology. In this sense, as Widodo et al. (2021) describe, the concept of *"The Seven Wastes"* (p. 777), which can be implemented in both the service and manufacturing industries, includes the different typologies of waste, which are related to excessive transportation, unnecessary inventory, unnecessary movement, waiting times, overproduction, overprocessing and defects.

Harmon (2014) also explores and explains individually each category of waste, which do not add value to organisations and affect its performance. In this regard, according to the same author, excessive transportation is linked to unnecessary movements of materials and information that can damage the product, increase the work and effort required, and generally lead to various types of costs that impact the value of the process. Unnecessary inventory refers, as the author states, to the accumulation of unused inventory with additional costs to organisations. Harmon (2014) also points out that unnecessary movement impairs the tasks' performance and its execution time, and that waiting time refers to periods of inactivity prejudicial to the process, as no value is added to it and the delivery of the product / service on time is compromised. Furthermore, the same author states that overproduction occurs when the production process generates more outputs than the required or when these are generated ahead of time, while overprocessing is concerned with processes that hold effort, components or even procedures in excess of what is demanded by the customer, for example *"any extra operation, any rework"* (p. 319) that needs to be done. Lastly, as characterised by the author, defects are all the outputs that are not accepted by the customers or by the following processes.

Bakke and Johansen (2019) in addition to these seven typologies of waste, present another category known as *"skills misuse"* (p. 375), which refers to the incorrect use of competences and skills, that is, the poor exploitation of talents and abilities.

2.2.4. Tools

There are several possible tools that can be used to implement lean methodology, as shown by the authors Purushothaman et al. (2020), Bakke and Johansen (2019) and Vamsi and Sharma (2014). Through these tools it is then possible to improve the organisations' processes and increase their

efficiency and performance. The selection of the tool to be used depends not only on the company's objectives but also on the available resources. Some of those techniques that enable the identification and later elimination of possible waste are Value Stream Mapping (VSM), Kanban and Kaizen, as mentioned by the authors Kumar et al. (2018) and Singh and Sharma (2009). Besides these tools, the authors Tayal and Kalsi (2021), Dresch et al. (2019) and Benjamin et al. (2013) also present some other techniques applied to implement lean methodology, in particular the Single Minute Exchange of Die (SMED), the 5S, the Fishbone Diagram, the Pareto Chart, the Visual Management and the Standard Work. All these tools are recognised as useful in the food manufacturing sector, as argued by Kennedy et al. (2013).

As previously mentioned, value stream refers to the set of activities required to deliver a given product to the customer, which add value or not (Singh & Sharma, 2009). VSM corresponds to the direct analysis of the material and information flows related to a process, which enables the identification of activities that do not add value to the business and the detection of delays in the process (Vamsi & Sharma, 2014; Singh & Sharma, 2009).

Kanban is another tool used to implement the lean methodology. According to the authors Harmon (2014) and Singh and Sharma (2009), this tool, that means card in Japanese, uses constantly cards in its activities that allow to better manage and plan the flow of products of a given organisation. In this sense, it is found that the main focus of this tool corresponds to an inventory reduction in the organization (Singh & Sharma, 2009). Bass (2016) also states that with this tool it is intended to visualize more clearly the flow of products, to facilitate the identification of *"backlogs, blockages and bottlenecks"* (p. 3).

Kumar et al. (2018) present the Kaizen technique, which corresponds to another tool of the lean methodology. This increasingly popular tool, according to Kumar et al. (2018), is related to continuous improvement, which aims to support the elimination of waste in the organisation, contributing to an increase in quality, productivity and performance of the process (Kumar et al., 2018).

According to Singh et al. (2018) and Benjamin et al. (2013), the SMED technique is a lean tool often used to reduce downtime losses in organisations. Through this technique, as Benjamin et al. (2013) state, organisations aim to significantly improve the short stoppage time losses involved in production processes, more specifically in setup and changeover activities. Indeed, as Singh et al. (2018) clarify, the meaning of SMED does not imply that all activities in question should take less than a minute to perform, but rather that the total duration of execution should be accomplished in less than 10 minutes, which is in a *"single-digit minute"* (p. 2068). Therefore, through a set of practices designed to simplify and standardise the operations involved in those activities, SMED enables the reduction of non-productive time, the elimination of waste, and also allows processes to become more flexible, thus contributing to improvements in organisational performance (Singh et al., 2018; Benjamin et al.,

2013). Furthermore, as noted by Singh et al. (2018) and Benjamin et al. (2013), reducing start-up and transition times gives the opportunity to increase available capacity along with reducing costs, which translates into an advantage for organisations.

Concerning 5S, and in accordance with Tayal and Kalsi (2021) and Gupta and Jain (2015), this tool is based on the following five practices: Sort (classify the existing elements in the workplace, remove unnecessary and obsolete items, and keep the ones that are essential to perform the activities), Straighten (store and organise efficiently the items classified as essential in specific places and under certain criteria), Shine (keep the area clean and tidy), Standardise (establish procedures to ensure a caring and structured working environment over time), Sustain (make a commitment to preserve the workplace by regularly applying the previous practices). Some organisations, as reported by Randhawa and Ahuja (2017), suggest the addition of another practice concerned with safety in the work area, and so the traditional 5S is converted to 6S. In this sense, the implementation of this tool benefits organisations by reducing waste, improving quality and increasing efficiency and productivity (Tayal & Kalsi, 2021; Gupta & Jain, 2015).

The fishbone diagram, also known as the cause-effect diagram or Ishikawa diagram, represents another tool of the lean methodology (Tayal & Kalsi, 2021; Zahrotun & Taufiq, 2018). The purpose of applying this diagram is to identify the possible causes for a given problem (Tayal & Kalsi, 2021). In this way, as Suárez-Barraza and Rodríguez-González (2019) explain, this tool allows, by starting from the most general to the most specific, to detail the possible causes of a problem or non-conformity and thus determine the root causes for the effect under study, and create an action plan to solve them. This diagram, which corresponds to a graphic and visual representation, is divided into different categories in order to classify the possible causes according to this criterion, and with sub-sections it is intended to find the real root cause (Tayal & Kalsi, 2021; Suárez-Barraza & Rodríguez-González, 2019). With the application of this tool the efficiency of the processes can be improved, as well as the organisational performance.

The Pareto chart is a commonly used lean tool, allowing organisations to focus on the problems/wastes with most relevance and impact in its processes (Tayal & Kalsi, 2021; Benjamin et al., 2015; Murugaiah et al., 2010). As Tayal and Kalsi (2021) note, this technique is based on the 80/20 principle, where *"80% of the problems rise from 20% of its causes"* (p. 1986). In this way, by classifying and prioritising problems, organisations are able to direct its action plans towards the most important problems, leading to more efficient processes (Benjamin et al., 2015; Murugaiah et al., 2010).

Visual management, according to Ulhassan et al. (2015), aims to facilitate communication in the workplace through simple visual instruments with core information for the performance of the process. Along this view, as Dresch et al. (2019) and Parry and Turner (2006) state, visual management intends to improve processes in different sectors by providing immediate, transparent and clear

informative support about the process, allowing to guide and coordinate the collaborators involved in the process.

Another tool associated to the lean methodology corresponds to the standard work, which according to Boettcher et al. (2019) and Dresch et al. (2019), is an instrument that allows establishing activities and procedures to be followed to perform a certain process. Realyvásquez-Vargas et al. (2019) corroborate this idea when stating that by following certain established instructions it becomes possible to achieve a more efficient process. Indeed, as Dresch et al. (2019) and Realyvásquez-Vargas et al. (2019) argue, by creating a procedure regarding the sequence of tasks to be performed and defining the best methods to be pursued, processes can be more easily executed in a correct and consistent way, leading to a maximisation of productivity and a reduction of wastes.

One should however note that these different tools can be adopted either individually and also simultaneously, in a complementary way in order to make the lean methodology implementation process more effective and efficient (Jimenez et al., 2019). The diversity of ways to apply these lean tools is analysed below for the particular case of the food manufacturing sector.

2.2.5. Lean in Food Manufacturing

The following first three studies illustrate the individual application in food production and manufacturing processes of some of the lean tools previously discussed, with the aim of increasing the performance of the organisations under analysis. While the last three studies presented below demonstrate the potential of applying different tools together as a way of ensuring a successful outcome with regard to process improvements.

In the study described by the authors Garcia-Garcia et al. (2022), relating to a ready-to-eat meal manufacturing company in the UK, the lean SMED tool was implemented to reduce waste associated with complex changeover processes, increase equipment performance and decrease labour costs. With the adoption of lean manufacturing principles, the company was able to improve productivity and efficiency in its production processes, as noted by Garcia-Garcia et al. (2022).

According to the study provided by Mazelan et al. (2021), in the context of noodles production, lean techniques were adopted to improve the two areas of the production line with the highest percentage of waste, the mixing and the packaging ones. Therefore, with the implementation of the action plans, improvements were achieved in the identified areas, since the causes of waste were analysed and addressed with the support of the fishbone diagram, contributing to an increase in the overall performance of the production process (Mazelan et al., 2021).

The implementation of this methodology is also evident in the study presented by Bamford et al. (2015), with the purpose of improving the efficiency and performance of the production processes in two plants of a food manufacturing company in the UK. Through the adoption of lean principles and

some techniques related to this philosophy, such as the Kanban control system, the company was able to eliminate waste, embrace new working methods and enhance operational efficiency (Bamford et al., 2015).

In accordance with the study shown by Jimenez et al. (2019), the application of this methodology is evident in the proposals developed to enhance the production process of a fish and seafood processing and marketing company. With the support of some lean tools, for instance the VSM, the Pareto chart, the fishbone diagram and the 5S, the activities that do not add value to the process were identified, to be subsequently eliminated according to the suggested proposals, with the aim of reducing processing times and respective costs, and thus making the processes more efficient (Jimenez et al., 2019).

Maalouf and Zaduminska (2019) introduce another study related to the implementation of the lean methodology in a company in the food processing industry, with the analysis being focused on the herring salad production line. The use of two lean tools, VSM and SMED, allowed the company to increase production capacity, as well as reduce waste related to transition time and setup time, which contributed to decrease the total production cycle time, and thereby enhance the efficiency of the process (Maalouf & Zaduminska, 2019).

Furthermore, Kennedy et al. (2013) also explore the same topic by presenting a study conducted in a frozen ready meal manufacturing company, who benefited from the implementation of this methodology. The introduction of several lean practices and the application of some of its tools, in this case the Pareto chart, 5S and SMED, led to more efficient processes, waste reduction at different stages of the production cycle, lower costs, as well as better working environment conditions, which offers more competitive advantages to the company (Kennedy et al., 2013).

In conclusion, as highlighted by the previous studies, the application of the lean methodology in the food sector enables an increase in efficiency and effectiveness of the most varied processes, such as the production and manufacturing ones, as well as a decrease in waste, resulting in better organisational performance.

2.3. Conclusion

In this chapter a theoretical knowledge is provided regarding the subject, in this case related to business process changes, starting from the general to the particular in its different approaches.

Based on the different studies reviewed, it becomes clear that, in order to make changes at process level, organisations should analyse the different possibilities of methodologies and respective tools available to apply, and understand whether they are suitable for the type of business and its objectives.

Considering the main purpose of this work, which involves the improvement of production processes, as well as the elimination of waste existing in the processes, the methodology that best suits the interests of the organisation and the project finality corresponds to the lean approach. More specifically in the context of food manufacturing, the studies analysed corroborate the applicability of the lean methodology in organisational processes and also emphasise the advantages and benefits linked to its adoption.

In addition, according to the literature, there are several useful tools, which based on the studies presented, some show great potential of use for this study, including VSM, Kanban, Kaizen, SMED, 5S, Fishbone Diagram, Pareto Chart, Visual Management and Standard Work.

Therefore, it is expected that this project provides a significant contribution to the company under consideration. Furthermore, due to the limited number of studies applied in food manufacturing, this study has the potential to contribute to the literature.

3. METHODOLOGY

The methodology of a project refers to the way in which the project will be conducted to guarantee the accomplishment of the proposed objectives. In this context, the procedures adopted in the present project and the details of its different phases are described in this section.

3.1. Action Research Methodology

As already mentioned, action research corresponds to the methodology applied in this project, since it is a project, developed in the company itself, with the aim of solving a real problem, in which all participants are extremely involved in the process and also in the organisation, and are aware of all the progress achieved (Coghlan & Brannick, 2005).

An active collaboration, as argued by Saunders et al. (2016) and Coghlan and Brannick (2005), enables organisations to understand the different perspectives of the participants and, on that basis, to develop and subsequently implement solutions that contribute to the improvement of its processes. Furthermore, the integration of all members participating in the process allows a better understanding regarding the real difficulties and the flaws that need to be addressed, in order to make the processes more efficient and effective (Saunders et al., 2016).

Indeed, the participatory nature is evident in this in-company project since, with the purpose of improving the effectiveness and efficiency of the production process X, it relies on the support of multiple departments, interested in contributing to the improvement of Company B's performance, as well as on the cooperation of the several collaborators directly working with the process under study.

In this project a mixed method approach is applied together with the action research methodology (Ivankova & Wingo, 2018). This mixed methodology follows an embedded design, in which both qualitative and qualitative methods are used together to collect and analyse data in a complementary way (Ivankova & Wingo, 2018). The qualitative methods used in this study include direct observation, semi-structured interviews and open-question surveys. As for the quantitative methods used, these involve direct observation and closed-question surveys.

A more detailed description is provided below regarding the nature of the sources of data, as well as the different techniques adopted in the processes of data collection and analysis.

3.2. Action Research Cycle

Regarding the action research cycle, as Coughlan and Coghlan (2009) note, there are some slightly adapted models presented by different authors, but all of them have the same basis, which is to integrate action and thought into a single approach to cooperatively solve real problems with different types of knowledge. The core steps related to this methodology, according to Coghlan and Brannick (2005), include identifying the existing problems in the organisation, making a plan to solve the

problem, implementing and then evaluating and analysing the results of these actions in order to repeat, if necessary, the cycle again and adopt new ones. Alongside this cycle, the reflection cycle is also operating, as it is crucial to review how the different stages are being performed.

In line with the key activities that are characteristic of the action research methodology, the cycle on which the development of this in-company project is based corresponds to an adaptation of the ones presented by Coghlan and Brannick (2005) and Coughlan and Coghlan (2002). This combination arises as both of these two models have distinct meta-phases, the monitoring one and the reflection one, which, in the context of this project, when combined, appear to be very useful and beneficial. Furthermore, the authors Coughlan and Coghlan (2002) divide the process of data collection, feedback and analysis into individual stages, which according to the framework presented by Coghlan and Brannick (2005) are all part of the diagnosis phase. For the purpose of this project the diagnosis phase proposed by Coghlan and Brannick (2005) is used.

Therefore, as illustrated in Figure 3.1, the followed action research cycle is composed by a previous phase of contextualization and objectives statement, a problem diagnosis step, a stage related to the action planning, a phase regarding its implementations and another one about the evaluation of the adopted measures. Furthermore, this cycle also includes a meta-phase, which involves the monitoring and reflection activities conducted during the whole project (based on Coghlan and Brannick (2005) and Coughlan and Coghlan (2002), as explained above).

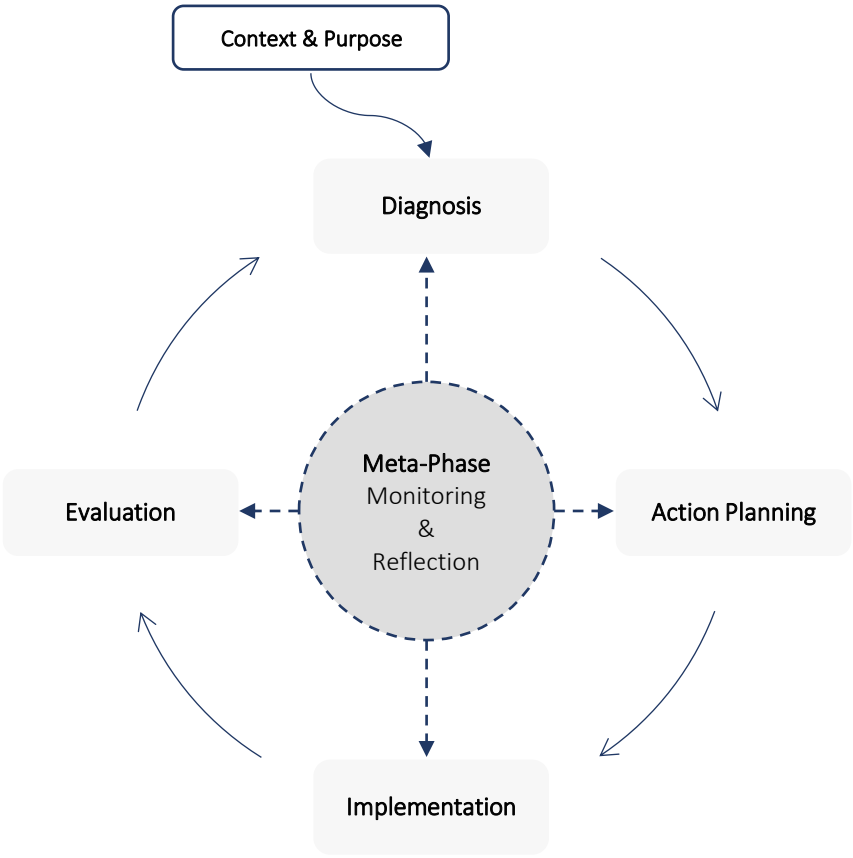


Figure 3.1. Action Research Cycle. Source: Adapted from Coghlan & Brannick (2005) and Coughlan & Coghlan (2002)

3.2.1. Pre-Phase: Context and Purpose

The preliminary step, as the name suggests, relates to the framing of the action research project, as well as the identification of the underlying purpose. In this way, according to Coghlan and Brannick (2005) and Coughlan and Coghlan (2002), this pre-step aims to ground the action and the research, introducing the rationales for the need to develop and study this project, as well as clarifying the relevance of this type of methodology to the knowledge acquisition.

In this particular project, this introductory stage involves an overview of Company B's operational processes and the presentation of the members participating in the project, as a way to start creating a cooperative relationship. It also involves stablishing the challenges to be addressed within the scope of this project, which is to improve the effectiveness and efficiency of the manufacturing process of round cakes, as detailed in Chapter 1.

3.2.2. Diagnosis

After understanding all the conjuncture inherent to the project to be developed, the first major phase of the action research cycle is carried out. The diagnosis phase is concerned with the identification and description of the potential issues to be addressed in the project, as well as the collection, feedback and analysis processes of the corresponding data (Coughlan & Coghlan, 2002). Along with the active participation of different stakeholders, several methods are also used to support the activities required in this stage (Coghlan & Brannick, 2005; Coughlan & Coghlan, 2002).

Concerning the project under study, the diagnosis phase is related to the tracking and subsequent analysis of the production process X, the one proposed by Company B, with the aim of identifying inefficiencies and inefficiencies affecting the production line.

As previously mentioned, a mixed methods approach is used at this stage, in which the methods applied depend on the typology of the problem. Accordingly, both quantitative and qualitative methods are used for data collection and analysis.

Data Collection

In this manner, a variety of qualitative data collection methods are used. Particularly, for both inefficiency and ineffectiveness problems, several semi-structured interviews are performed with collaborators involved in the process, including:

- Line operators, to recognise the process and identify potential problems and the corresponding causes. The questions asked to the line operators are structured as follows:
  - What is the production process of round cakes like? What are the stages involved in its manufacturing?

    - Is there usually a significant incidence of problems in the production process? If yes, what are the most frequent problems or which ones affect your work the most, and what are the underlying causes?
    - Can you explain the criteria behind the product selection or rejection process? If yes, what are they?
    - Do you know why some round cakes come with defects?
- Maintenance technicians, to identify the problems and the underlying causes. The interview questions for maintenance technicians are organised according to the following guidelines:
    - Some problems have been identified in process X regarding product waste, is there any possible causes that are related to the equipment or its maintenance? If yes, what are they?
    - With regard to inefficiency issues, are you aware of any more than the ones identified? Do you know some of the potential causes of these inefficiency problems? If yes, can you explain them?
- Maintenance supervisor and production line supervisor, for identification, validation and selection of the most critical problems. For the supervisors, the questions are structured in the following format:
    - Can you confirm the existence of the problems identified on the production line under study?
    - Considering the causes detected, which ones have the highest priority to be addressed?
    - Are there other issues that are not being addressed and that are of high relevance? If yes, which ones?
    - On the basis of the problems classified as having the highest priority, can its analysis be pursued?

Direct observation is also used to complement the information gathered through the interviews, in order to understand how the process works and what are its main inefficiencies issues and possible causes. In addition, open-ended questionnaires (more details can be found on Chapter 4) are used to gather feedback from line operators and maintenance technicians about the impact caused by the inefficiency issues previously identified in the process.

Based on the data gathered using these qualitative data collection tools, it is possible to build an As-Is flowchart of the initial process before any changes. In this case, the initial mapping of the process under study is developed through the Bizagi software.

Quantitative methods are also used for diagnosis purposes. Regarding ineffectiveness problems, direct observation is performed during two weeks, between the months of November and December 2021, to count the number of occurrences of defective products. Additionally, the use of closed-ended

questionnaires (more details can be found on Chapter 4) provides an understanding of the different perspectives of line operators and maintenance technicians concerning the identified inefficiency problems influencing the process performance.

Data Analysis

In terms of the data analysis process, both qualitative and quantitative methods are applied. The word clouds, one of the qualitative methods used in this process of the project under study, corresponds to a visual representation of the words most frequently mentioned. In this case, it is used to analyse the answers provided by the line operators and the maintenance technicians in the open-ended questions of the surveys performed, with respect to inefficiency problems. The identification of topics, patterns and categories regarding the results obtained from the questionnaires corresponds to another qualitative method used in this project for data analysis.

For the quantitative analysis methods, the frequency of responses to the questionnaires is used to understand the participants' opinions about the identified problems of inefficiency. Besides, the descriptive analysis of the nonconforming product count data, obtained through direct observation, is also used to extract relevant information and support the decision-making process against the product waste ineffectiveness problem.

Furthermore, considering the project's objective, which includes the reduction of waste, the lean philosophy is at the basis of this project, and therefore it is also relevant to present the different lean tools and practices adopted. In this diagnosis phase a number of lean tools are applied, in particular the fishbone diagram and the 5 Whys analysis to determine the root causes of the problems identified, allowing a corrective action plan to be defined. The 5 Whys, according to Benjamin et al. (2015), is often used to eliminate waste in organisations. Murugaiah et al. (2010) also demonstrate that, by repeatedly questioning the *why* of a non-conformity, it is intended to obtain the deeper cause, i.e., the real cause of the problem, and thus act on it to reduce or even eliminate the defects. Thereby, the use of both these tools enables a more accurate visualization and determination of the real causes behind the problems, with the support of information gathered through the interviews and questionnaires mentioned before.

Also related to the lean tools used in this phase, the Pareto chart is build using the Excel tool to identify the causes of the ineffectiveness problems with the highest impact or importance in the process.

3.2.3. Action Planning

Once the problems have been identified and the corresponding data analysed, the next step is the planning of action. As stated by Coghlan and Brannick (2005) and Coughlan and Coghlan (2002), this

phase consists in collaboratively developing the action plans intended to solve the issues previously specified. In this sense, besides the creation of different improvement proposals, it is also in this stage that a decision is formulated, jointly with the participants in the process, about the plan of action to be followed (Coghlan & Brannick, 2005; Coughlan & Coghlan, 2002).

This phase, in the scope of the present project, involves the creation of solutions alongside different members of the organisation, to discover potential alternatives concerning the approach to be used for dealing with the main sources of the inefficiency and ineffectiveness problems.

In this sense, viable solutions are sought for the causes mentioned by line operators, maintenance technicians and supervisors in the semi-structured interviews conducted in the previous phase. Therefore, different ideas of solutions to the inefficiency problems are detected through questionnaires made to the line operators, the maintenance technicians and the supervisors. These questionnaires, with closed and open-ended questions (more details can be found on Chapter 4), allow validating proposed solutions based on the literature review and questioning collaborators on additional suggestions or ideas. Also, for problems of inefficiency, semi-structured interviews are conducted with supervisors, to decide and approve the solutions to be implemented. These interviews are mainly centred on the questions: *"From the proposed solutions, which ones should be applied and for what reasons?"*; *"Do you have any other suggestions that should be considered?"*.

Moreover, with regard to ineffectiveness issues, semi-structured interviews are also used at this stage with the purpose of taking into consideration the solutions suggested for the identified main causes of product rejection. At this stage of action planning, the main focus of the semi-structured interviews, carried out with line operators, maintenance technicians and supervisors, is essentially based on the following questions: *"Regarding the ineffectiveness problems, do you have any suggestions for addressing the major root causes identified? If yes, what are the possible solutions for dealing with the main sources of product defects?"*.

With all this information gathered from the different participants, it is then possible to incorporate it into the action plan of this project, which aims to establish feasible solutions for each one of the priority causes that need to be improved.

In this case, the development of the action plan comprises the presentation of a plan proposal to the superiors, its reformulation in line with the opinion and suggestions expressed and, subsequently, its final approval.

According to the literature review, different lean tools have potential for application to address some of the recognised challenges, including the techniques of 5S, Visual Management and Standard Work.

3.2.4. Implementation

With the agreement of the participants regarding the interventions to be made, the next step is the implementation of the respective action plans. Coghlan and Brannick (2005) and Coughlan and Coghlan (2002) describe this implementation phase, also known as action taking, as the stage in which the measures presented in the previous phase are indeed applied to improve the organisation's problems. Therefore, the action moves from plan to practice, supported by the participants who coordinate the progress of the measures decided to be implemented (Coughlan & Coghlan, 2002).

Regarding the project under analysis, this implementation phase represents the actions executed to overcome the inefficiency and ineffectiveness problems initially identified. Therefore, the interventions, focused on eliminating the main sources of the issues, are linked to the practical implementation of the improvement proposals, which through photographic records can be visualised and thus better understood.

Essentially, this phase consists of the practical application of the solutions approved in the previous phase, intended to overcome the underlying problems and thereby lead to a more effective and efficient production process.

3.2.5. Evaluation

Following all the actions introduced, it is important to analyse the outcomes achieved with the implemented improvements. The evaluation phase aims to assess whether the whole process was correctly conducted, from the diagnosis stage to the implementation of the actions (Coghlan & Brannick, 2005). Thus, with the analysis and comparison of the before and after scenario regarding the implementation of improvements, one can understand the points that still need to be refined and the failures, to avoid committing the same mistakes in the next cycle (Coughlan & Coghlan, 2002). As such, this stage provides evidence of the success or unsuccess of the initiatives undertaken, and also allows the impact of the respective interventions on the organisation to be verified.

This phase, as far as the project in question is concerned, relies in part on feedback from the participants, who evaluate this process, and it depends also on the comparison between the pre-and post-changes scenario.

In this way, satisfaction questionnaires are carried out on participants, in particular line operators, maintenance technicians and supervisors, who individually assess the different actions performed to address the inefficiency problems of the production line. The open-ended questions (more details can be found on Chapter 4) used in these surveys enable suggestions, comments or ideas to be collected from the participants, that are of interest for further improvements in the process. In addition, closed-ended questions (more details can be found on Chapter 4) are also included to understand the participants' level of satisfaction with the implemented improvements. The methods used at this stage

to analyse the data gathered from the questionnaires correspond to the answers' frequencies, the word clouds and the identification of topics, patterns and categories.

Furthermore, in terms of ineffectiveness problems, direct observation is also used during this phase, to count the defective product after the interventions in the production process, thus enabling comparisons to be made with the data collected before the changes. With the descriptive analysis of the data of defective products before and after the changes made to the process, the level of success of the project with respect to ineffectiveness problems can be verified, in line with the pre-defined objectives.

Moreover, with the support of images taken before and after the interventions, it is possible to compare them and draw some conclusions about the changes made, in order to understand their impacts on the production process.

3.2.6. Meta-Phase: Monitoring and Reflection

The meta-phase corresponds to the phase that occurs in parallel with the main stages already discussed (Coghlan & Brannick, 2005; Coughlan & Coghlan, 2002). From this perspective, the meta-phase, by combining monitoring and reflection, allows not only to control and supervise the progress of the project (Coughlan & Coghlan, 2002), but also to reflect on the lessons learnt with the development of the project (Coghlan & Brannick, 2005). In this way, the monitoring and reflection that takes place at each of the stages allows useful knowledge to be generated and captured for a better performance of the project underway and any other future ones.

The meta-phase applied in this project also operates throughout the different stages of the action research cycle, with the aim of following closely the course of the project and acquiring useful insights on the way it is developed, leading to the decision about whether or not similar practices should be adopted in future stages/projects.

Above all, the meta-phase used in this project focuses essentially on how to maintain or improve the performance of the production process, but also on learning about what can be prevented in the future, in order to avoid inefficiency and ineffectiveness problems in the process that compromise the productivity.

4. CASE STUDY

The current section is dedicated to the case study, concerning the project developed in order to achieve the objectives initially established. In this sense, a detailed description is provided about the development of the project under study, focused on the production line of round cakes, throughout its different stages, following the action research cycle presented in Chapter 3.

The analysis and discussion of the results obtained in the different phases of the project is also provided in this section.

4.1. Context and Purpose

This project, developed in the food manufacturing company B, with presence in Portugal, started in October 2021. The first few weeks consisted mainly in introducing the nature of the company under study in terms of its values, mission and objectives, as well as providing a contextualisation of its several operational areas.

This introductory phase gave the opportunity to meet several collaborators from a wide range of departments, whose feedback helped to better understand the organisation as a whole. A detailed knowledge of the production processes was acquired through a deeper interaction with the maintenance and production departments.

During this period, the purpose of this project and the many participants involved in it were presented by the company. In accordance with the company, the round cake production line was underperforming, so this project's main focus was to significantly improve its productivity. In this sense, the improvement of this process was therefore based on addressing the existing inefficiencies and ineffectiveness that compromised the operational activity, and also affected the organisation's business.

Besides the introduction of the project's key purpose, at this stage some problems identified by the company were also presented as a justification for the need to develop the study in question. The considerable amount of product rejected due to non-compliance with the acceptance criteria was one of the problems reported by the company, with significant influence on the effectiveness of the process. Beyond this wastage, the company also reported other inefficiencies, linked in this case to the amount of time consumed in specific tasks of the process and to errors involved in its performance, which ultimately resulted in negative effects on the production flow.

The importance of this project was also highlighted, with a potential for future replication and adaptation in the other manufacturing processes also operated by the company. This underlined the relevance of retaining the knowledge gained from the development of this project.

4.2. Diagnosis

Once the scope and purpose of the project was clearly established, helpful for a deeper understanding, the diagnosis phase began, related to the collection and analysis of data on the inefficiency and ineffectiveness problems found in process X. The diagnosis phase starts with a description of the processes, as shown below.

4.2.1. Process Mapping

The flowchart illustrated in Figure 4.1 shows the several operations included in the production of the round cakes, from its raw materials to the storage of the final product.

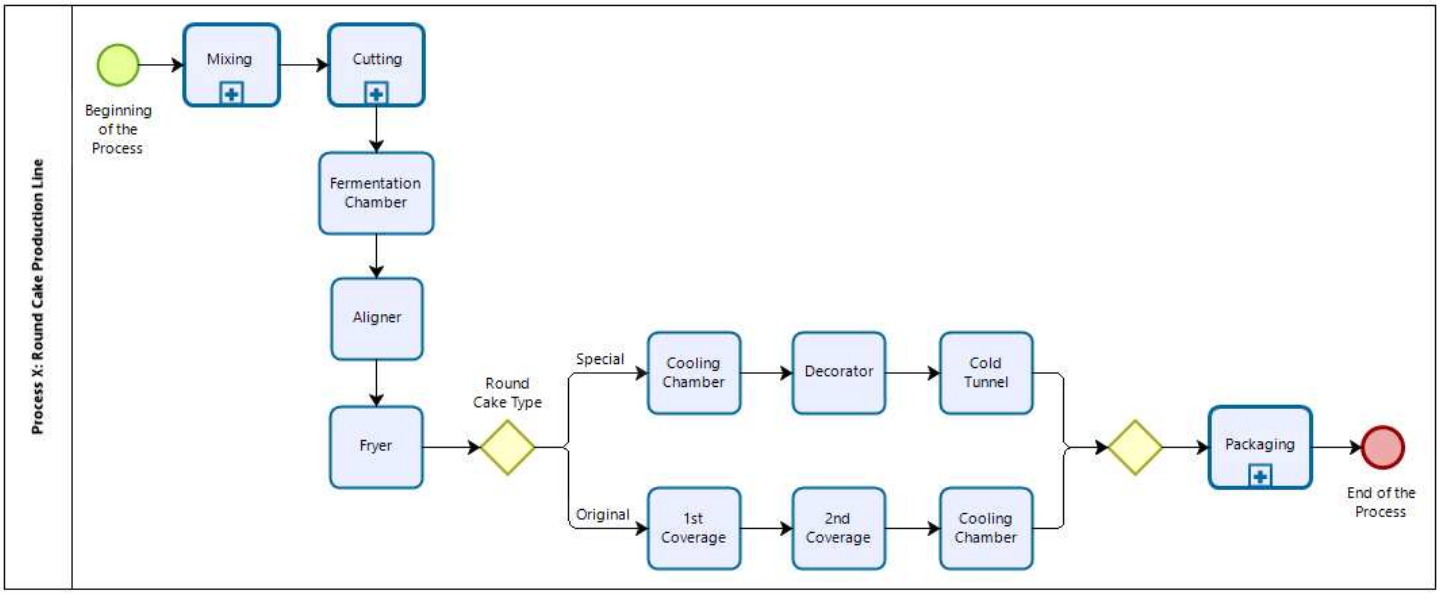


Figure 4.1. Flowchart of the production process of round cakes

According to Figure 4.1, the process begins with the mixing sub-process, presented in Figure 4.2, comprising the joining of the raw materials and the blending of the dough produced in two separate kneading machines.

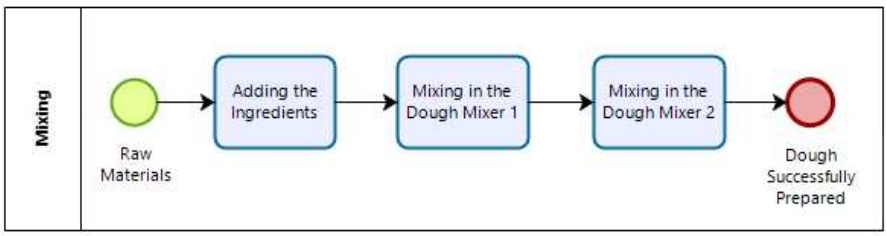


Figure 4.2. Flowchart of the mixing sub-process

Once the dough has been prepared, the next sub-process is the cutting of the dough, illustrated in Figure 4.3, where it is transferred to one of the cutters, which cuts it and places the cut dough on a shelf. During this sub-process, a control is performed on the weight of the cut dough, which, if it is not

within the acceptance interval defined by the company, requires adjustments to be made to the cutter parameters by the operator.

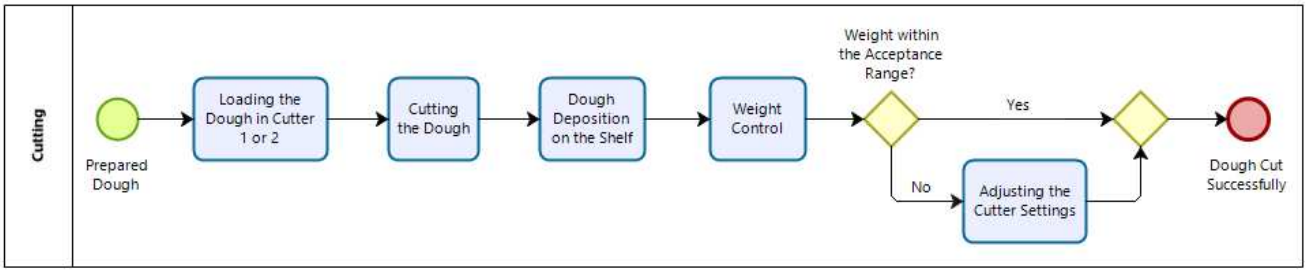


Figure 4.3. Flowchart of the cutting sub-process

Then, as shown in the Figure 4.1, the shelves filled with the cut dough go into the fermentation chamber for a specific period of time. After fermentation, the dough is placed in a conveyor, so an aligner arranges the positioning of the cakes, facilitating its transfer to the fryer. Following the frying phase, depending on the nature of the product, two distinct flows can be pursued until the packing phase. In the case of the original round cakes, after frying there follows the coating phase of the cake, composed by two layers of covering, applied sequentially. After the second coating, the cake goes into the cooling chamber, where it remains for a set period of time. For the special round cakes, after being fried, the cakes go into the cooling chamber for a defined amount of time. The decoration phase of the cakes takes place after the cooling phase, where other elements are added to the product, such as fillings or toppings. From the decorating machine, the cake goes through a cold tunnel to consolidate the product with the other ingredients added. In the packaging sub-process, the operations are similar regardless of the product category, as shown in Figure 4.4, starting with the placement of the cake inside the packaging, which is then sealed with film and cut. The next step is stamping the date and code on the pack, which is then moved to the cartoning machine where, except for the pack of 2 units, it is grouped and a cardboard strip is placed to attach the packs together. After the cartoning machine, the weight of the packs is checked. If the packs are not within the approval ranges established by the company, packages are put aside to be further separated and, if in perfect condition, returned to the cartoning machine. If neither the product nor the packaging is in conformity, the pack is rejected and not re-integrated into the packaging process. Once the weight of the packs has been validated, the packages go through a metal detector to ensure that there are no metallic materials. If any metal is detected, the packs in question are rejected and the quality department is notified so that the situation can be analysed. If no metallic material is detected, the packs are placed on pallets and stored for later dispatch.

As illustrated in Figure 4.1, the round cake production process ends with the packaging and storage of the final product. With this detailed view about the processes, and following the

methodology described in Chapter 3, a set of interviews and questionnaires were used to identify the causes of the problems (ineffectiveness and inefficiency).

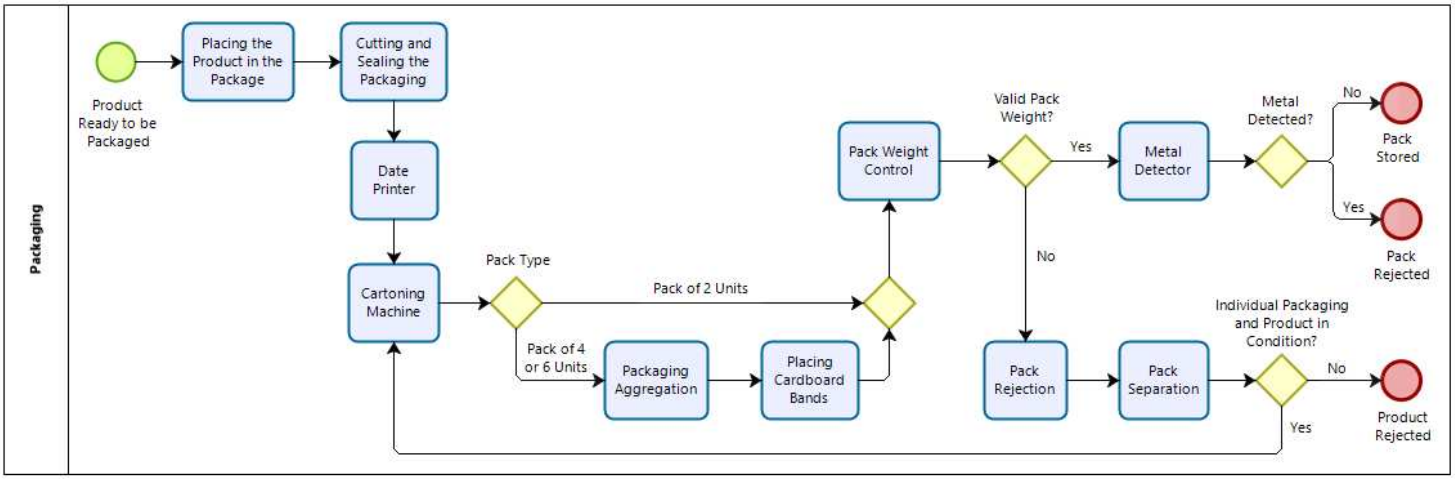


Figure 4.4. Flowchart of the packaging sub-process

4.2.2. Inefficiency Problems

Interviews

Concerning inefficiency issues, interviews have shown that this are partly linked to the time used in some tasks, which did not correspond to the main activities of the process, but which were crucial in ensuring the correct functioning of the production process. The line operators and the maintenance technicians helped to identify the tasks in which an excessive amount of time is consumed: the amount of time spent from the moment a breakdown occurs until the maintenance team provides assistance; the time and errors related to the operation of some equipment; the time spent by technicians searching for the information needed to solve equipment problems. Moreover, the supervisors also noted in the interviews the intensive use of paper, to record several information and details regarding the process, as an inefficiency of the production process.

Questionnaires

For each of the inefficiency problems identified, surveys (detailed in Appendix A) were conducted with the participants directly affected, namely the line operators and the maintenance technicians. In this context, one of the questionnaires performed to the production line operators was related to the communication gaps with the maintenance team (detailed in Appendix A.1), in case of line malfunctions that ended up interfering with the production efficiency. In this survey, operators were asked, firstly, to rate the waiting time for technical support (question 1; using a five-level scale comprising *Very Long*, *Long*, *Normal*, *Fast* and *Very Fast*) and, secondly, to classify the time spent looking for a technician to provide assistance (question 2; using a five-level scale comprising *Very Long*, *Long*, *Normal*, *Fast* and *Very Fast*). In addition, the potential reasons for the delay by the specialised

help were ultimately requested (question 3). Therefore, as presented in Table 4.1, the first two questions show the same median value, indicating that operators considered that both the waiting time and the time of searching for support were time-consuming.

Table 4.1. Questions 1 and 2 from the diagnosis phase questionnaire on communication with the maintenance team

Communication with Maintenance Team				
n = 15				
OPTION	**QUESTION 1**		**QUESTION 2**	
Very Long	1	6.7%	3	20%
Long	8	53.3%	5	33.(3)%
Normal	5	33.3%	5	33.(3)%
Fast	1	6.7%	2	13.(3)%
Very Fast	0	0%	0	0%
TOTAL	15	100%	15	100%
MEDIAN	**LONG**		**LONG**	

Additionally, as evidenced in Table 4.2, operators considered the lack of availability of technicians as the main reason for the long delay.

Table 4.2. Question 3 from the diagnosis phase questionnaire on communication with the maintenance team

Communication with Maintenance Team			
n = 15			
OPTION		**QUESTION 3**	
A	Physical Distance	2	11.76%
B	Lack of Communication Equipment on the Line	7	41.18%
C	Lack of availability of technicians	8	47.06%
D	Other	0	0%
TOTAL		17*	100%
MODE		**OPTION C**	

***Multiple answers allowed per participant**

One more questionnaire (detailed in Appendix A.2) was also answered by the line operators regarding the identification of the existing equipment on the production line, with the aim of understanding the level of necessity in solving this issue. According to Table 4.3, the majority of the participants disagreed about having ever pressed a wrong button on the equipment due to its incorrect labelling (question 1) and also about the difficulty in understanding the functionality of the equipment's buttons (question 2).

Table 4.3. Questions 1, 2, 4 and 5 from the diagnosis phase questionnaire on equipment identification

Equipment Identification								
n = 16								
OPTION	**QUESTION 1**		**QUESTION 2**		**QUESTION 4**		**QUESTION 5**	
Disagree	12	75%	13	81.25%	3	18.75%	11	68.75%
Neither Agree Nor Disagree	1	6.25%	1	6.25%	0	0%	1	6.25%
Agree	3	18.75%	2	12.5%	13	81.25%	4	25%
TOTAL	16	100%	16	100%	16	100%	16	100%
MEDIAN	**DISAGREE**		**DISAGREE**		**AGREE**		**DISAGREE**	

The two participants who found the functionalities difficult to understand stated, as indicated in Table 4.4, that the lack of buttons identification and its degradation were the principal explanations for such difficulty (question 3). With regard to the ability of selecting the appropriate equipment option (question 4), approximately 81% of the participants claimed to have needed the help of co-workers, as highlighted in Table 4.3. And when asked to consider a scenario in which the participants were

recently hired for the position (question 5), approximately 69% of the operators agreed that it would be difficult to autonomously and easily understand the functionalities of the existing buttons on the equipment, as displayed in Table 4.3.

Table 4.4. Question 3 from the diagnosis phase questionnaire on equipment identification

Equipment Identification			
n = 2			
OPTION		QUESTION 3	
A	No Identification	2	50%
B	Wrong Identification	0	0%
C	Wear of Identification (E.g. Cleaning)	2	50%
D	Other	0	0%
TOTAL		4*	100%
MODE		OPTION A OPTION C	

***Multiple answers allowed per participant**

From the responses listed in Table 4.5 to the open-ended question about the explanation of this difficulty (question 6), it was noted that it was either related to insufficient practice as a result of being new to the production line and therefore not being allowed to make decisions about selecting equipment options, or to inadequate or non-existent labelling of equipment buttons.

Table 4.5. Question 6 from the diagnosis phase questionnaire on equipment identification

Equipment Identification	
n = 11	
QUESTION 6	
ANSWERS	Because new employees are not allowed to touch the equipment
	Lack of identification
	When we start working on a new production line, we are accompanied by the line responsible who will explain things to us, so we don't touch the buttons without knowing their functions
	On my own I wouldn't be able to understand the functions of the buttons because I don't know the line and the equipment very well yet
	We cannot touch the equipment until we have authorisation from the line responsible
	Lack of knowledge
	For the fact that I am new in the company/production line
	Because we could not touch the equipment at an early stage and some of them had no identification on the buttons
	Various equipment all different from each other and with different functions
	Because I am not yet "trained" about the equipment

The questionnaire conducted to the maintenance technicians, regarding technical support documents (detailed in Appendix A.3), such as instruction manuals and detailed information about equipment, allowed a better understanding of how the arrangement of documentation influences the performance of the technicians' activities. In a first phase, the technicians were questioned about the frequency of use of technical documents (question 1), and around 63% stated using these materials at least once a week, as shown in Table 4.6.

Table 4.6. Question 1 from the diagnosis phase questionnaire on documentation

Documentation			
n = 8			
OPTION		QUESTION 1	
A	Every Day	1	12.5%
B	Once a Week	5	62.5%
C	Fortnightly	1	12.5%
D	Once a month	0	0%
E	Rarely	1	12.5%
F	Never	0	0%
TOTAL		8	100%
MEDIAN		OPTION B	

In the case of the technician, who indicated that he rarely accessed these documents, the justification for this was related to the non-need for consulting the files (question 2), as illustrated in Table 4.7.

Table 4.7. Question 2 from the diagnosis phase questionnaire on documentation

Documentation			
n = 1			
OPTION		QUESTION 2	
A	Disorganised Documents	0	0%
B	Outdated Documents	0	0%
C	Wear and Tear of Documents	0	0%
D	No Need	1	100%
E	Other	0	0%
TOTAL		1	100%
MODE		OPTION D	

Regarding the search for the desired documents (question 3), approximately 50% of the technicians classified (using a five-level scale comprising *Very Difficult*, *Difficult*, *Normal*, *Easy* and *Very Easy*) this task as being hard to accomplish, as highlighted in Table 4.8.

Table 4.8. Question 3 from the diagnosis phase questionnaire on documentation

Documentation		
n = 8		
OPTION	QUESTION 3	
Very Difficult	1	12.5%
Difficult	4	50%
Normal	2	25%
Easy	1	12.5%
Very Easy	0	0%
TOTAL	8	100%
MEDIAN	DIFFICULT	

Regarding the potential reasons for this delay (question 4), according to Table 4.9, 75% of the technicians considered the disorganisation of the documents as the main justification.

Table 4.9. Question 4 from the diagnosis phase questionnaire on documentation

Documentation			
n = 8			
OPTION		QUESTION 4	
A	Disorganised Documents	6	75%
B	Outdated Documents	2	25%
C	Other	0	0%
TOTAL		8	100%
MODE		OPTION A	

When asked about the presence of obsolete documents kept together with the updated files (question 5), only one technician answered that there were no archives in that condition, as shown in Table 4.10.

Table 4.10. Question 5 from the diagnosis phase questionnaire on documentation

Documentation		
n = 8		
OPTION	QUESTION 5	
Disagree	1	12.5%
Neither Agree Nor Disagree	0	0%
Agree	7	87.5%
TOTAL	8	100%
MEDIAN	DISAGREE	

For the other technicians, who stated that there were obsolete documents, it was asked through an open question to list those files (question 6).[1]

Fishbone Diagram and 5 Whys

Following the identification of the inefficiency problems, it was possible to proceed with the analysis of the corresponding causes. In this regard, a single fishbone diagram was constructed, illustrated in Figure 4.5, in which the main categories represented each of the inefficiencies previously mentioned. With the interviews and the information gathered through the questionnaire, it was possible to complete the diagram and detail for each problem the related potential causes, which ultimately also affected the overall efficiency of process X. The application of the 5 Whys technique allowed, in some cases, to determine not only the causes, but also the underlying sub-causes, enabling subsequent actions to be focused on the source of the problem.

Ideally, all the causes detailed in the fishbone diagram should be addressed to ensure the elimination of all identified inefficiencies that compromise production performance. However, in practice it is not always possible to act on all problems at once, so it is important to prioritise and understand which ones are feasible to be tackled given a range of other factors involved. In this instance, the selection has to be made considering the goals and plans of the organisation. In an interview with the supervisors, it was discussed which causes would be worked on at an early stage and the rationale behind that choice. The selected causes for intervention chosen by the supervisors are outlined in orange in the fishbone diagram, shown in Figure 4.5.

Regarding the communication problem with the maintenance technicians, whose delays compromise the production process, the corresponding root causes selected to be improved were the absence of communication devices on the production line and the sub-causes linked to the improper use of the devices that were used by the technicians to contact with each other. The other two causes concerning this problem were not selected, since the issue of the physical distance between the production line and the maintenance workshop was not easily fixable, and it was also not possible to overcome the technicians' availability issue without hiring new ones, which according to the supervisors at the time was not viable.

With regard to the issues related to equipment identification and its technical documentation, all the root causes listed in the diagram were selected by supervisors to be solved.

As for the problem of the process being paper-based, by decision of the organisation itself, it was decided not to deal with that issue at that time, since it was not a priority given that other relevant changes were under development.

[1] Due to the fact that these responses contain confidential information, it could not be presented in the thesis.

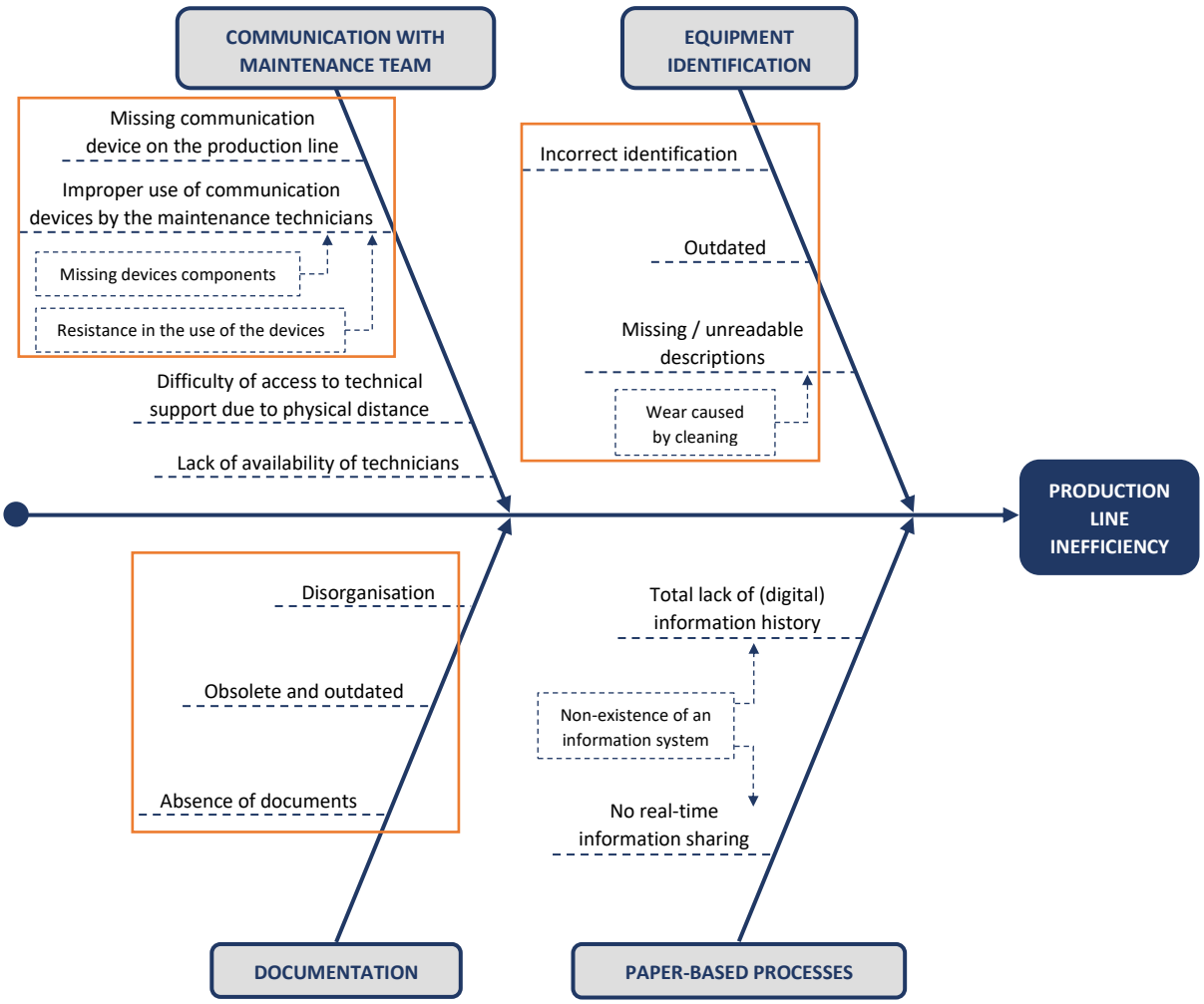


Figure 4.5. Fishbone diagram of production line inefficiency problems

4.2.3. Ineffectiveness Problems

Interviews

In the pre-phase, as previously explained, the organization expressed a special interest in intervening in a specific area of the production line with a substantial record of rejected product. Therefore, by solving these problems associated with product waste, it was intended to increase the effectiveness of the process and its performance.

Initially, line operators were interviewed to understand the underlying reasons for product rejection and to determine the different categories of problems. The categories of rejected product according to the typology of the cake defect were established as a result of these interviews, these being the following classifications of the cake: *small*; *large*; *cut*; *misshapen*; *with particles* (remnants of dough); *without coverage* (or with flaws); *crumpled*; *uncooked*; *without consistency*; *broken*; *glued*; *burnt*; *stained*.

Direct Observation and Pareto Chart

Once identified the ineffectiveness issues, the production was followed and analysed in order to determine the frequency of defects by typology. In this context, through direct observation of the process, the volume of products rejected due to non-conformities and defects was collected and recorded. This counting of defective product was performed over a period of two weeks, allowing valuable information to be obtained to support the decision-making process. From the gathered data, it was possible to compile the Table 4.11, which contains, for each one of the different types of defects, the corresponding percentages of occurrence.

Table 4.11. Percentages of occurrence by product defect category

FREQUENCY	CATEGORY	%
1º	Misshapen	22.55%
2º	Large	17.01%
3º	Glued	13.15%
4º	Uncooked	12.62%
5º	Cut	11.03%
6º	With Particles	10.20%
7º	Stained	4.45%
8º	Small	4.19%
9º	Crumpled	3.93%
10º	Burnt	0.54%
11º	Without Coverage	0.26%
12º	Broken	0.04%
13º	Without Consistency	0.03%

According to Table 4.11, it was verified that *misshapen* cakes corresponded to the defect category with the highest level of occurrence, more specifically around 23% of the products with defects presented this type of condition. On the other hand, as evidenced in Table 4.11, *broken* and *without consistency* cakes corresponded to the defect categories with the lowest incidence percentage, with the respective values 0.04% and 0.03%.

Since it was not feasible to solve all the defects identified in the Table 4.11, the Pareto rule was used to select the 20% of defects that corresponds to the 80% of the occurrences, being those the ones that need to be solved within the scope of this project.

The Pareto chart, shown in Figure 4.6, was thus built using data available in Appendix B.1, being possible to conclude that there were two defects that were mandatory to be solved (*misshapen* and *large*). The next four defects (classified as B according to the Pareto rule; *glued*, *uncooked*, *cut* and *with particles*) were also presented to the company, so as to evaluate their interest in also dealing with it.

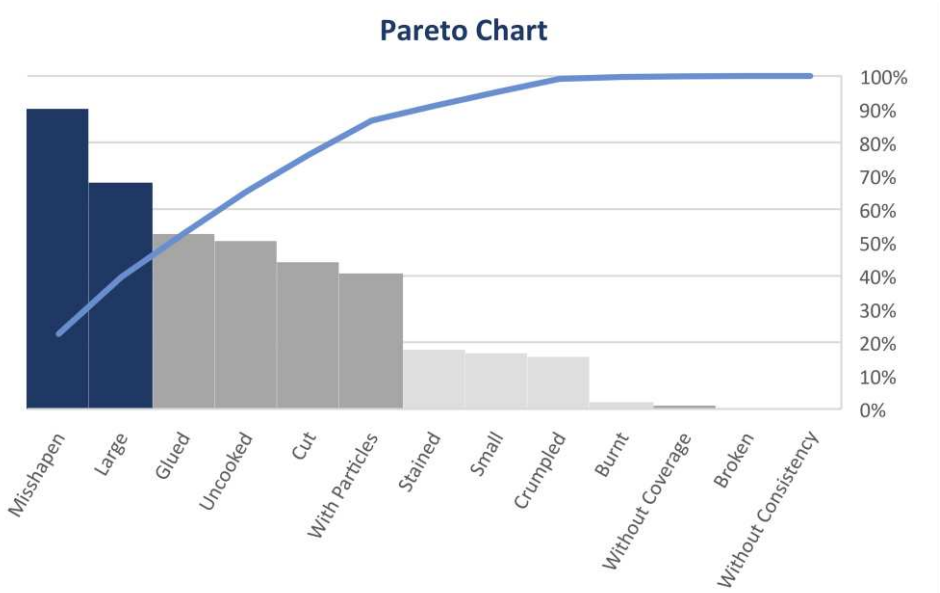


Figure 4.6. Pareto chart of production line ineffectiveness problems

Fishbone Diagram and 5 Whys

In line with the organisation's priorities, the six categories with the highest occurrence and impact on the effectiveness of the process were selected to be under investigation. A more detailed analysis of the corresponding defects was then conducted with the purpose of being able, in a further phase, to act on the source of the faults. Therefore, through interviews, several causes linked to each one of the categories were found, which allowed creating the fishbone diagram illustrated in Figure 4.7. Furthermore, the 5 Whys analysis also enabled detecting sub-causes underneath some of the causes that lead to product defects, also shown in the diagram of Figure 4.7.

As was the case for inefficiency problems, not all the causes presented in the diagram related to ineffectiveness issues were covered due to different reasons. In this context, interviews were conducted with supervisors to reveal the multiple causes identified for round cake wastage, as well as to decide which ones, besides having been studied, should be addressed in practice. This selection, carried out by the organisation, was made due to several circumstances that prevented the simultaneous intervention of all the defect categories shown in the diagram. Therefore, considering the resources available at the time, the technicians' availability and other top priority plans in the company's agenda, a decision was taken with the supervisors to initially proceed with the resolution of some of the causes, highlighted in the diagram in orange, which gave rise to four of the six categories of defects studied in more detail. Some of the causes corresponding to these four categories of defects, which were the ones with the highest occurrence and comprised *misshapen cake*, *large cake*, *glued cake* and *uncooked cake*, were not addressed given the company's priority.

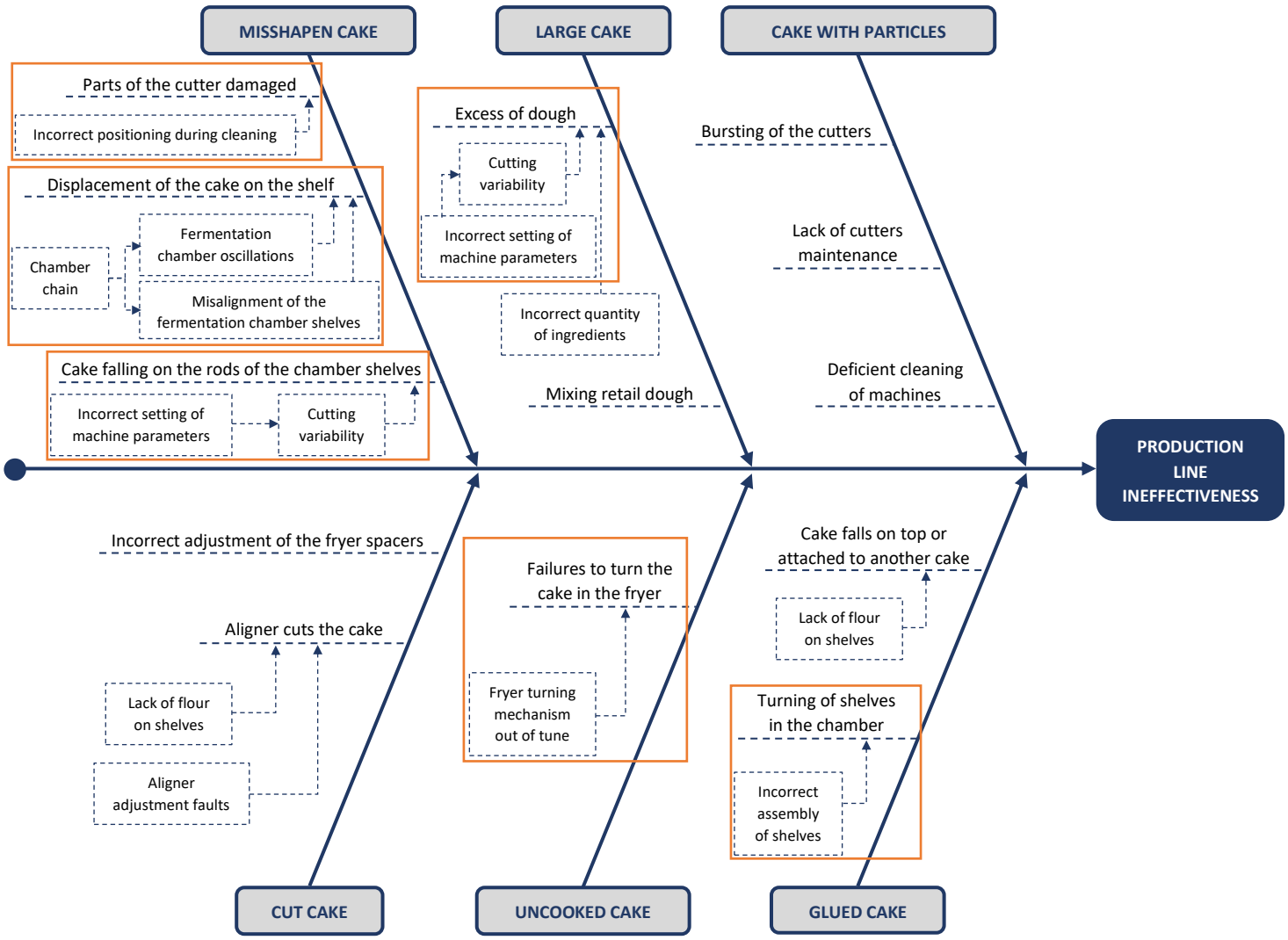


Figure 4.7. Fishbone diagram of production line ineffectiveness problems

4.3. Action Planning

Once the causes to be worked on were established, it was possible to move on to the next phase of planning the interventions with the aim of searching for potential solutions to the identified and selected causes.

4.3.1. Inefficiency Problems

Questionnaires

In the case of inefficiency problems, surveys (detailed in Appendix C) were conducted with the involved participants to explore alternative options and to verify the proposed suggestions.

Regarding the communication issue with the maintenance team (questionnaire detailed in Appendix C.1), as represented in Table 4.12, all participants agreed on the benefits offered by the implementation of a radio in the production line (question 1).

Table 4.12. Questions 1 and 3 from the action planning phase questionnaire on communication with the maintenance team

Communication with Maintenance Team				
n = 15				
OPTION	**QUESTION 1**		**QUESTION 3**	
Disagree	0	0%	11	73%
Neither Agree Nor Disagree	0	0%	0	0%
Agree	15	100%	4	27%
TOTAL	15	100%	15	100%
MEDIAN	**AGREE**		**DISAGREE**	

As shown in Table 4.13, approximately 63% of the interviewees considered that with a radio on the production line, the time spent searching for technical support would be considerably reduced (question 2).

Table 4.13. Question 2 from the action planning phase questionnaire on communication with the maintenance team

Communication with Maintenance Team			
n = 15			
OPTION		**QUESTION 2**	
A	Less time removing cake (Rework)	9	37.5%
B	Less time looking for assistance (Tiredness)	15	62.5%
C	Other	0	0%
TOTAL		24*	100%
MODE		**OPTION B**	

***Multiple answers allowed per participant**

When asked about other possible solutions to improve communication between the production line and maintenance technicians (question 3), only 27% of the respondents affirmed having other suggestions, as illustrated in Table 4.12. The ideas suggested by the participants (question 4), indicated in Table 4.14, were essentially related either to the allocation of a line manager in charge of communicating directly with the technicians, or to the assignment of a technician to each production line, or to placing a phone on the line or even a warning button.

Table 4.14. Question 4 from the action planning phase questionnaire on communication with the maintenance team

Communication with Maintenance Team	
n = 4	
QUESTION 4	
ANSWERS	Line responsible
	Warning button
	Phone on the production line
	A technician for each of the production lines

Concerning the identification of the equipment on the production line (detailed in Appendix C.2), as shown in Table 4.15, 94% of the participants strongly expressed agreement with the idea of updating the labels for all the equipment (question 1), as a way to improve decision making by reducing time and mistakes.

Table 4.15. Questions 1 and 2 from the action planning phase questionnaire on equipment identification

Equipment Identification				
n = 16				
OPTION	**QUESTION 1**		**QUESTION 2**	
Disagree	0	0%	16	100%
Neither Agree Nor Disagree	1	6%	0	0%
Agree	15	94%	0	0%
TOTAL	16	100%	16	100%
MEDIAN	**AGREE**		**DISAGREE**	

When questioned about other suggestions that could constitute alternative solutions to the one presented, none of the participants brought up additional ideas (question 2), as can be verified by Table 4.15.

As for the documentation of the technical files of the equipment available on the production line (detailed in Appendix C.3), the interviewees were questioned about ideas to facilitate the process of searching for the desired files (question 1), and as displayed in Table 4.16, 75% claimed to have some ideas for this improvement.

Table 4.16. Questions 1 and 3 from the action planning phase questionnaire on documentation

Documentation				
n = 8				
OPTION	**QUESTION 1**		**QUESTION 3**	
Disagree	2	25%	0	0%
Neither Agree Nor Disagree	0	0%	0	0%
Agree	6	75%	8	100%
TOTAL	8	100%	8	100%
MEDIAN	**AGREE**		**AGREE**	

Those six participants were therefore asked to describe the suggestions (question 2) which, according to Table 4.17 that lists the replies to this open question, it was noted that the suggestions proposed were related to the rearrangement and updating of documentation per lines and per sections, only for the equipment existing at the time in the production area.

Table 4.17. Question 2 from the action planning phase questionnaire on documentation

Documentation	
n = 6	
QUESTION 2	
ANSWERS	Filing according to production lines
	Add missing documentation; Rearrange documents
	Create sections
	Split documents by production lines
	Identify cabinets by production line and by area
	Remove old documents/manuals and reorganise

Also according to Figure 4.8, these suggestions were mostly characterised by the concepts highlighted in the word cloud, with the expression *production line* being the most mentioned, followed by the *create section* term.

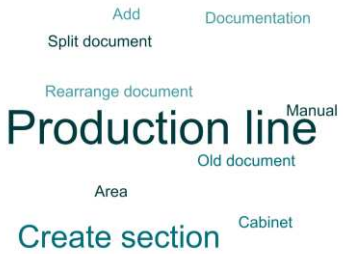


Figure 4.8. Word cloud of question 6 from the action planning phase questionnaire on documentation

Furthermore, as illustrated in Table 4.16, there was agreement from all participants that the proposed idea of organising the archives using a colour system for each line and a numbering scheme

with an index (question 3) would significantly reduce the time spent on searching for the required documents.

Interviews

On the basis of the information gathered through the questionnaires, the different alternatives proposed were then assessed and the respective solutions to be applied to overcome the multiple root causes of these problems were defined. For this purpose, interviews were conducted with the supervisors for establishing the solutions that would be subsequently adopted. A number of decisions emerged from the interviews, evidenced in Table 4.18, which presents the solutions to be implemented to address the underlying causes.

Table 4.18. Approaches for solving each selected root cause of inefficiency problems

PROBLEM	ROOT CAUSE	SOLUTIONS
COMMUNICATION WITH MAINTENANCE TEAM	Missing communication device in the production line	Communication device in production line
	Missing device components	Acquisition of missing components
	Resistance in the use of the devices	Training workshop
EQUIPMENT IDENTIFIICATION	Incorrect identification	New labels (Visual Management)
	Outdated	
	Wear caused by cleaning	
DOCUMENTATION	Obsolete and outdated documents	Documents organisation by lines and areas (5 S)
	Disorganisation	
	Absence of documents	

For the different causes selected concerning the communication issue with the maintenance team, a number of distinct solutions were established, including the implementation of a communication device on the production line, the acquisition of its missing parts (components whose absence were preventing the appropriate use of the devices), and the encouragement and awareness-raising among the maintenance technicians on the importance of the communication and its impact on productivity, through a training workshop. The other ideas suggested to solve this problem were not adopted since, according to the supervisors, the assignment of a technician to each line had already been applied in the past without bringing any positive effect. With regard to the warning button and the phone, these involved changes with more associated costs, and presented a disadvantage, as if the technician was not in the maintenance workshop the warning or phone call probably would not be known.

The solution defined to improve the problems associated with equipment identification involved the implementation of the visual management concept, through the application of new, updated, hard-to-wear and easy-to-understand labels.

In terms of the issues linked to documentation, the solution established focused on updating and reorganising files by production line and by the different areas of the production processes, through the implementation of the 5S tool.

4.3.2. Ineffectiveness Problems

For ineffectiveness problems, the identification of potential actions was carried out through interviews with different participants. Therefore, as shown in Table 4.19, some solutions were established for each of the root causes selected, most of which were related to work standardisation based on work instructions and the correspondent training.

Table 4.19. Approaches for solving each selected root cause of ineffectiveness problems

CATEGORY	ROOT CAUSE	SOLUTIONS
MISSHAPEN	Incorrect positioning during cleaning	Work instruction Training
	Chamber chain	Chain replacement
	Incorrect setting of machine parameters (Pressure regulation)	Work instruction Training
LARGE	Incorrect setting of machine parameters (Pressure regulation)	Work instruction Training
UNCOOKED	Fryer turning mechanism out of tune	Work instruction Training
GLUED	Incorrect assembly of shelves	Training

These solutions, proposed by the interviewees, were also reviewed and validated with the supervisors, considering the priorities and goals of the company.

4.4. Implementation

Once the solutions to be applied were defined, the corresponding implementations were undertaken with the aim of improving both the efficiency and effectiveness of the round cake production process.

4.4.1. Inefficiency Problems

Communication with Maintenance Team

According to the previous phase, to overcome the communication challenges between the production line and the maintenance technicians it was decided to implement a communication device on the line, to purchase components of the devices that were missing, as well as to educate the technicians on its proper use and its importance.

In this context, since the technicians already used radios on a daily basis to contact each other, it was decided that this would be the communication device to be implemented. In this way, it was first needed to determine the number of radios that were at the time in good condition in the maintenance workshop and compare it with the number of radios required on a daily basis, having in account the number of technicians per shift. From this analysis, it was found that the number of radios available at the time was suitable to implement one on the round cake production line without having to order new ones. However, it was detected that the radios were in good condition, but some of them did not contain a critical piece essential for its use by the technicians, the clip. Consequently, only this inexpensive missing item was ordered, allowing a proper use of the radios.

Moreover, to overcome the technicians' gap in the proper use of the device, an awareness training session was conducted by the maintenance department manager, to instigate its use and to clarify the key role of communication for a better work performance.

After these interventions, all the conditions were established to install the radio on the production line (illustrated in Appendix D.1). A line operator was assigned to ensure the correct management of radio usage and to minimise interference in communication, so that all the information is properly conveyed to technicians.

Equipment Identification

New labels were the selected solution to solve the issue arising from the inefficient equipment identification. With regard to the adoption of this solution, it was first required to collect information needed for the new labels from the different equipment installed on the production line. Interviews were conducted with maintenance technicians, specialists in the equipment, and with line operators, who deal with it on a daily basis, in order to gather the desired details, such as description, size, quantity and the corresponding equipment. The main focus of these interviews was to obtain the right identification of the equipment options with the following question: *"Can you explain the buttons' function and give a description for each one of them, so that the corresponding labels can be created?"*. After the collected data was analysed, the new labels, composed by a more resistant material, were ordered. Once the order arrived, the labels were divided according to the equipment, facilitating the replacement of the old labels by the new ones and, in some cases, its application on buttons without any description (illustrated in Appendix D.2).

Documentation

The action selected to overcome the inefficiencies derived from the documentation problems corresponded to the 5S tool, intended to facilitate the search process for the desired archives, as well as to update and organise the space where the files are stored.

The first step (Sort) consisted in compiling an Excel register with a list of all the documents existing at the beginning of the project, removing the files identified as obsolete, which were stored in a designated location for those files (illustrated in Appendix D.3), and subsequently updating the register with that new information about the old documents. At this stage, interviews were conducted with the different maintenance technicians for classifying the documentation according to the operational status of the corresponding equipment. In this way, the interviews were essentially based on the separation of the existing files from the outdated ones, with the following question: *"Do you know if the equipment related to this documentation is still in activity or if it is obsolete?"*.

After separating the unnecessary files, whose equipment was no longer operational, it was possible to proceed with the organisation of the documents from the equipment in activity at the time. This second step of 5S (Set in Order) focused on the adoption of a system to facilitate the search, use and storage of the files. Therefore, a colour system was adopted for each line and the files were numbered and ordered according to the location of the corresponding equipment, from the area of the raw materials to the packaging section. At this stage, the number of files updated at that time was also determined to proceed with the materials ordering. As a result, all the files, which were already showing signs of wear and tear, were replaced with new ones, as well as identified with an attached spine, according to the respective line and production area. Moreover, during the shift of files to the new dossiers the contents were also analysed to confirm if the documents were archived in the corresponding folder. As part of this phase of checking the information in the archives, the technicians were interviewed to ensure that the documentation was correctly stored according to the equipment. In this context, the questions asked to the technicians were the following: *"Can you confirm that the documents in the folder in fact match the corresponding equipment? If not, can you indicate the equipment to which these files belong?"*.

With this organisation, the next phase (Shine) was taken, which involved cleaning the place where these documents were stored, in order to eliminate any accumulation of dirt and to leave the space tidy and clean.

The following step (Standardise) included the creation of an index for each production line, with the numbering of the multiple related files and its brief description, ordered by manufacturing area. These indexes, intended to facilitate the location of the desired documents, were displayed both on the outside of the cabinets, and also inside them, to reduce the time spent searching in case technicians forget the reference number of the needed file. Furthermore, each shelf was also properly identified with the name of each production line to avoid mistakes in the storage of the documents.

The last step of 5S (Sustain) relied on the commitment embraced by the technicians to keep this workplace constantly clean and organised, as illustrated in Appendix D.4, for the benefit of all.

4.4.2. Ineffectiveness Problems

For addressing the selected problems of ineffectiveness, most of the actions defined relied on the development of working instructions, inexistent at the time, for some of the different root causes. For the development of these work instructions, interviews were conducted with both maintenance technicians and line operators, with the aim of understanding the procedure that should be standardised and followed by all. These interviews focused mainly on the questions: *"What are the fundamental steps that should be followed to correctly perform this task?"*; *"Can you explain why it should be done in a certain way and not in another?"*.

This standardisation was applied to overcome the rejection of round cakes, whose defects corresponded to deformed, large, uncooked and glued. With the contribution of line operators and maintenance technicians, three work instructions were drawn up. In this way, to avoid damaging the cutters during cleaning, the steps that should be taken to correctly handle the material in this process were established and are detailed in Appendix E.1. As regards the irregular dropping of the cake on the shelf, which results in its deformation, and the incorrect volume of dough cut, which in excess leads to oversized cakes, a common root cause was identified. In this sense, a work instruction was created with the procedures to be followed for the correct pressure regulation, provided in Appendix E.2, so that variability in the dough cutting process could be reduced. Concerning the uncooked cakes, caused by the out of sync of the fryer turner with the cake positioning, a work instruction containing the several steps that must be taken into account for a correct adjustment of the turner was developed, and can be found in Appendix E.3.

Besides the work instructions, the line operators were also trained about the respective problems addressed, to ensure that the information provided in these standardisation procedures was understood.

The only solution capable of tackling the issue related to the fermentation chamber from scratch was its complete replacement (illustrated in Appendix E.4), as mentioned before. In this context, since it was a complex and technical problem, the intervention required the involvement of a range of maintenance technicians and it was necessary, alongside the production department, to schedule a production stoppage to properly proceed with the changeover, which, with shifts working without interruptions, took almost two days.

For reducing or even eliminating the defect of *glued* cakes, due to the incorrect assembly of the shelves in the fermentation chamber, training was given to the maintenance technicians to ensure that this task was performed properly. Therefore, a maintenance technician with experience in this subject shared this knowledge with the other technicians to guarantee that each one knew how to correctly perform this work.

4.5. Evaluation

With all the interventions completed in response to the identified issues that significantly affected the process X performance, an evaluation of the implemented actions was performed. The purpose of this evaluation was to understand the level of satisfaction of the different participants with the multiple improvements made, as well as to determine the impact of these interventions on the execution of the process and on productivity.

4.5.1. Inefficiency Problems

In the scope of the inefficiency problems, the assessment of the participants' satisfaction, through questionnaires (detailed in Appendix F) and subsequent data analysis, allowed to ascertain the success rate regarding the improvements applied.

From the questionnaire about the improvements in communication with the maintenance team (detailed in Appendix F.1), it was found that none of the participants was indifferent or dissatisfied with the implementation of the radio (question 1; using a five-level scale comprising *Very Dissatisfied*, *Dissatisfied*, *Neither Dissatisfied Nor Satisfied*, *Satisfied* and *Very Satisfied*), as shown in Table 4.20. Instead, about 83% of the respondents were satisfied with the implementation and the remaining 7% were very satisfied.

Table 4.20. Question 1 from the evaluation phase questionnaire on communication with the maintenance team

Communication with Maintenance Team			
n = 6			
OPTION		QUESTION 1	
1	Very Dissatisfied	0	0%
2	Dissatisfied	0	0%
3	Neither Satisfied Nor Satisfied	0	0%
4	Satisfied	5	83%
5	Very Satisfied	1	7%
TOTAL		6	100%
AVERAGE		4	

According to Table 4.21, 33% of the participants reported having already used the implemented communication device (question 2), and the remaining 67% declared having witnessed its use.

Table 4.21. Question 2 from the evaluation phase questionnaire on communication with the maintenance team

Communication with Maintenance Team			
n = 6			
OPTION		QUESTION 2	
A	No	0	0%
B	No, but I have seen it being used	4	67%
C	Yes	2	33%
TOTAL		6	100%
MODE		OPTION B	

When asked to rate the experience of using the radio (question 3; using a five-level scale comprising *Very Poor*, *Poor*, *Normal*, *Good* and *Very Good*), by themselves or by others, more than half of the respondents classified it as a positive experience, as evidenced in Table 4.22.

Table 4.22. Question 3 from the evaluation phase questionnaire on communication with the maintenance team

Communication with Maintenance Team		
n = 6		
OPTION	QUESTION 3	
Very Poor	0	0%
Poor	0	0%
Normal	2	33%
Good	4	67%
Very Good	0	0%
TOTAL	6	100%
MEDIAN	GOOD	

As shown in Table 4.23, all interviewees stated that the radio on the production line improved the communication with the maintenance technicians and consequently reduced the waiting times (question 4). No interviewees, in accordance with Table 4.23, provided other suggestions that could contribute to a better communication between departments (question 5).

Table 4.23. Questions 4 and 5 from the evaluation phase questionnaire on communication with the maintenance team

Communication with Maintenance Team				
n = 6				
OPTION	**QUESTION 4**		**QUESTION 5**	
Disagree	0	0%	6	100%
Neither Agree Nor Disagree	0	0%	0	0%
Agree	6	100%	0	0%
TOTAL	6	100%	6	100%
MEDIAN	**AGREE**		**DISAGREE**	

Concerning the measures implemented to overcome the problems associated with equipment identification (questionnaire detailed in Appendix F.2), as presented in Table 4.24, 50% of the participants were satisfied with the implementation of the new labels and the other 50% were very satisfied (question 1; using a five-level scale comprising *Very Dissatisfied*, *Dissatisfied*, *Neither Dissatisfied Nor Satisfied*, *Satisfied* and *Very Satisfied*).

Table 4.24. Question 1 from the evaluation phase questionnaire on equipment identification

Equipment Identification			
n = 6			
OPTION		**QUESTION 1**	
1	Very Dissatisfied	0	0%
2	Dissatisfied	0	0%
3	Neither Satisfied Nor Satisfied	0	0%
4	Satisfied	3	50%
5	Very Satisfied	3	50%
TOTAL		6	100%
AVERAGE		**4.5**	

In line with Table 4.25, all participants mentioned that this improvement allowed making the decision process in selecting buttons faster, easier and more error-free (question 2), as well as facilitating the participants' work and at the same time helping in the learning process of the new collaborators (question 3).

Table 4.25. Questions 2, 3 and 4 from the evaluation phase questionnaire on equipment identification

Equipment Identification						
n = 6						
OPTION	**QUESTION 2**		**QUESTION 3**		**QUESTION 4**	
Disagree	0	0%	0	0%	6	100%
Neither Agree Nor Disagree	0	0%	0	0%	0	0%
Agree	6	100%	6	100%	0	0%
TOTAL	6	100%	6	100%	6	100%
MEDIAN	**AGREE**		**AGREE**		**DISAGREE**	

On being asked about other suggestions that could make this task more intuitive and faster, none of the respondents reported knowing of other possible ideas (question 4), as illustrated in Table 4.25.

About the interventions performed to increase the efficiency of the search process for the desired documentation (questionnaire detailed in Appendix F.3), as presented in Table 4.26, approximately

89% of the interviewees were very satisfied with the new file organisation system (question 1; using a five-level scale comprising *Very Dissatisfied*, *Dissatisfied*, *Neither Dissatisfied Nor Satisfied*, *Satisfied* and *Very Satisfied*).

Table 4.26. Question 1 from the evaluation phase questionnaire on documentation

Documentation			
n = 9			
OPTION		QUESTION 1	
1	Very Dissatisfied	0	0%
2	Dissatisfied	0	0%
3	Neither Satisfied Nor Satisfied	0	0%
4	Satisfied	1	11%
5	Very Satisfied	8	89%
TOTAL		9	100%
AVERAGE		5	

Also, as evidenced in Table 4.27, more than half of the participants stated that the search process with the newly implemented organisation format was less time consuming (question 2; using a five-level scale comprising *Very Long*, *Long*, *Normal*, *Fast* and *Very Fast*).

Table 4.27. Question 2 from the evaluation phase questionnaire on documentation

Documentation		
n = 9		
OPTION	QUESTION 2	
Very Long	0	0%
Long	0	0%
Normal	0	0%
Fast	6	67%
Very Fast	3	33%
TOTAL	9	100%
MEDIAN	FAST	

Additionally, all participants considered the new document organisation model as being intuitive and understandable (question 3), as displayed in Table 4.28. Regarding further suggestions, as illustrated in Table 4.28, only two participants claimed to have proposals for new ideas or future improvements (question 4).

Table 4.28. Questions 3 and 4 from the evaluation phase questionnaire on documentation

Documentation				
n = 9				
OPTION	QUESTION 3		QUESTION 4	
Disagree	0	0%	7	78%
Neither Agree Nor Disagree	0	0%	0	0%
Agree	9	100%	2	22%
TOTAL	9	100%	9	100%
MEDIAN	AGREE		DISAGREE	

The suggestions submitted by the two respondents (question 5), listed in Table 4.29, were related to the font size of the indexes, that could be larger, and to the files' identification, which could have a brief description of the archived documents, complemented by its numbering.

Table 4.29. Question 5 from the evaluation phase questionnaire on documentation

Documentation	
n = 9	
QUESTION 5	
ANSWER 1	Larger letters in the indexes; Spine of the dossiers with description
ANSWER 2	Folders with simple description

On this basis, it was possible to note that all participants were satisfied with the efforts made to cope with the inefficiency problems and recognised the benefits that these interventions brought to the production process.

Therefore, as demonstrated in Figure 4.9[2], illustrating the comparison of before and after the interventions, it was possible not only to create a cleaner and more functional workspace, but also to simplify by adopting a number of techniques the accomplishment of the corresponding tasks, as in the search for the required information, as for example in fully understanding the options available in the equipment, which as shown in the second improvement presented in Figure 4.9 there were extremely worn out labels and for that reason the corresponding description was unreadable.



Figure 4.9. Comparison of before and after interventions on inefficiency problems

4.5.2. Ineffectiveness Problems

The measures applied to overcome the ineffectiveness problems were evaluated by re-counting the defective products once all the interventions were performed. Therefore, for the same period of fifteen days as before, starting in June 2022 and ending in the beginning of August, a count of defective products was carried out through direct observation.

Afterwards, all the data collected was analysed using the Excel tool, enabling before and after comparisons to be made for all types of defects, as available in Appendix G.1. With regard to the four categories of defects studied in more detail, it was found that the corresponding percentages of occurrence decreased significantly, as shown in Table 4.30.

Table 4.30. Comparison of the percentages of occurrence before and after the interventions

CATEGORY	BEFORE (%)	AFTER (%)	Δ (%)
MISSHAPEN	22.55%	12.82%	-9.72%
LARGE	17.01%	11.94%	-5.07%
GLUED	13.15%	5.22%	-7.93%
UNCOOKED	12.62%	8.24%	-4.38%

[2] Due to the fact that the figures contain confidential information, to illustrate some of the improvements made, it was required to slightly blur the pictures.

The category with the highest percentage reduction was the misshapen cake, with a decrease of approximately 9.72%, as shown in Table 4.30, indicating that before the improvements about 23% of the defective cakes had this type of problem, and that after the implemented measures this number was reduced to almost 13%. The second most significant reduction was for glued cake, in about 7.93%, followed by large cake, in almost 5.07%, and then the uncooked cake, in approximately 4.38%, as presented in Table 4.30.

From these results, it was therefore evident that the interventions undertaken had a positive effect on the production process of round cakes, mainly in terms of effectiveness.

4.6. Monitoring and Reflection

The monitoring and reflection phase, which was carried out simultaneously with all the other phases of the project, helped to identify some relevant points.

In this context, some resistance was experienced, mostly at the beginning of the project, when the maintenance technicians, in particular, realised that some changes at the level of workplace organisation would be made. However, integrating them in this process made them understand the importance of these changes for a better and easier performance of their work. Therefore, the close monitoring and follow-up of the participants' response and how they managed the changes, was crucial to anticipate any eventual adverse effects that might affect the project. In addition, this monitoring allowed above all to understand the feedback from participants on aspects of the project that could have been enhanced.

It was also noticed that with the active cooperation of the different participants, the real causes of the problems were discovered, which without their contribution would probably not have been detected, what would prevent the achievement of results as favourable as those obtained with the project. Moreover, it was perceived that this involvement in a certain way changed the participants' mindset towards the project, as they started to be more proactive and to bring autonomously ideas and suggestions. In this way, the participants were actively engaged as they felt empowered to contribute to the improvement of the production process.

Some conclusions were drawn from this project, which should be taken into consideration in the future. The main lesson learnt, corroborated by this project, was the importance of including the different participants in every phase.

On the other hand, it was found that with the adoption of regular practices focused on constantly searching for improvements, the performance of processes can be maintained or improved. In order to guarantee the continuous tracking of the occurrences of product defects, a template in Excel to be filled in every two weeks with the amount of non-conforming products was proposed for further

implementation. With this practice, it is intended to instigate in employees a proactive attitude to act upon problems which, if not solved at the moment, may assume more significant proportions.

Furthermore, in order to ensure that the documentation is stored according to the implemented organisation format, it was suggested to set a visual model (picture) as a way to exemplify the correct arrangement of the technical documents at the workplace.

The purpose of the presented ideas is to introduce, in future projects/improvements, working and organisational methods in such a way that the interventions undertaken have an evolutionary effect and not a regressive one.

5. CONCLUSION

With the need to increase productivity and improve the performance of business processes, Company B showed interest in having the different phases of operational activities analysed in detail, and in particular those of the round cake production line. Other than that, other reasons that led to the need for improvement include the fact of essential tasks for the correct functioning of the process requiring a considerable amount of time to be completed and also the significant volume of product wasted due to defects.

For this purpose, this action research project was developed in order to answer the question *"How to improve the effectiveness and efficiency of the process X in company B?"*. Questionnaires, interviews and direct observation were used in a systematic way to collect the required information for the analysis and mapping of the process. These data collection methods were also useful to identify the problems and underlying causes affecting the production process, thus making it was possible to create and implement appropriate solutions for overcoming them. The introduced measures focused essentially on reducing failures in the process, as well as its associated waste, for which several lean tools were applied. The main solutions were based on tasks standardisation, using a set of operating guidelines to avoid any errors, on the correct identification of the equipment through its labelling, and also on the introduction of a more structured and organised model, with the use of the 5S tool, so as to reduce the time spent searching for the right information.

With the implementation of technical actions and the standardisation of procedures, a significant improvement was achieved by reducing the frequency of defects that most impacted the effectiveness of the production process. For the categories subject to intervention, which included misshapen, glued, large and uncooked, decreases were recorded of around 10%, 8%, 5% and 4%, respectively. Meanwhile, by introducing a range of specific measures (such as labelling system and documentation format), it was possible to address the existing inefficiencies in the process. Therefore, the gains obtained were essentially characterised by a reduction in the waiting time for technical support (communication with the maintenance team), in the time spent in the selection process (labelling of the equipment), as well as in the amount of time involved in searching for information (organisation of technical documentation). With these improvements, several wastes were eliminated, leading to an increase in the efficiency and effectiveness of the production process.

The company, based on the results obtained from the project under analysis, expressed the desire to replicate the methods used and practices adopted in the production process of round cakes, in the remaining production lines, to also improve their performance and productivity. This shows the success of the project regarding the objectives established and the outcomes achieved.

Nevertheless, although being concluded with success, several limitations and difficulties were dealt with during this project. For instance, it was observed that, in an early stage, some of the

collaborators were resistant to any changes that might be adopted, however this was overcome as they were more involved in the project and started to feel like a key element of it. Also, especially at the beginning of the project, the lack of information and the difficult access to it proved to be barriers that prevented the project from progressing more quickly.

Several ideas for further work can be presented. The remaining factors identified as potential causes of inefficiency and ineffectiveness of the process, which were not analysed in depth, may represent opportunities for future work, enabling a better operational performance to be obtained by addressing them. For instance, as environmental commitments become more relevant, one of the future projects likely to be applied in the organisation involves implementing an application to replace the daily use of paper records and therefore systematise in digital format all the information into a database accessible to everyone in real time.

Furthermore, in light with today's society, increasingly reliant on technology to achieve faster and greater results with fewer resources, another proposal for future work, with a bigger impact, entails the robotisation of the production line. With process automation, the company would be able to avoid problems arising from human failure, reduce costs and increase its productivity, features favourable to the organisations.

In conclusion, it can be said that there is still room for future projects capable of contributing, through the reduction of costs and waste, to a better success of company B.

REFERENCES

Abreu, J., Martins, P. V., Fernandes, S., & Zacarias, M. (2013). Business processes improvement on maintenance management: A case study. *Procedia Technology, 9*, 320-330. doi:10.1016/j.protcy.2013.12.036

Adesola, S., & Baines, T. (2005). Developing and evaluating a methodology for business process improvement. *Business Process Management Journal, 11*(1), 37-46. doi:10.1108/14637150510578719

Bakke, A., & Johansen, A. (2019). Implementing of lean – Challenges and lessons learned. *Procedia Computer Science, 164*, 373-380. doi:10.1016/j.procs.2019.12.196

Bamford, D., Forrester, P., Dehe, B., & Leese, R. G. (2015). Partial and iterative lean implementation: Two case studies. *International Journal of Operations & Production Management, 35*(5), 702-727. doi:10.1108/ijopm-07-2013-0329

Banga, J. R., Balsa-Canto, E., Moles, C. G., & Alonso, A. A. (2003). Improving food processing using modern optimization methods. *Trends in Food Science & Technology, 14*(4), 131-144. doi:10.1016/s0924-2244(03)00048-7

Bass, J. M. (2016). Improving writing processes using lean and kanban. *Learned Publishing, 29*(4), 307-310. doi:10.1002/leap.1045

Bendell, T. (2005). Structuring business process improvement methodologies. *Total Quality Management & Business Excellence, 16*(8-9), 969-978. doi:10.1080/14783360500163110

Benjamin, S. J., Marathamuthu, M. S., & Murugaiah, U. (2015). The use of 5-whys technique to eliminate OEE's speed loss in a manufacturing firm. *Journal of Quality in Maintenance Engineering, 21*(4), 419-435. doi:10.1108/jqme-09-2013-0062

Benjamin, S. J., Murugaiah, U., & Marathamuthu, M. S. (2013). The use of SMED to eliminate small stops in a manufacturing firm. *Journal of Manufacturing Technology Management, 24*(5), 792-807. doi:10.1108/17410381311328016

Boettcher, P. A., Hunter, R. B., & McGonagle, P. (2019). Using lean principles of standard work to improve clinical nursing performance. *Nursing Economics, 37*(3), 152-158.

Chen, X., Hellinga, B., Chang, C., & Fu, L. (2014). Optimization of headways with stop-skipping control: A case study of bus rapid transit system. *Journal of Advanced Transportation, 49*(3), 385-401. doi:10.1002/atr.1278

Chinosi, M., & Trombetta, A. (2012). BPMN: An introduction to the standard. *Computer Standards & Interfaces, 34*(1), 124-134. doi:10.1016/j.csi.2011.06.002

Ciancio, S. (2018). The prevalence of service excellence and the use of business process improvement methodologies in Australian universities. *Journal of Higher Education Policy and Management, 40*(2), 121-139. doi:10.1080/1360080x.2018.1426372

Coello Coello, C. A. (2006). Evolutionary multi-objective optimization: A historical view of the field. *IEEE Computational Intelligence Magazine, 1*(1), 28-36. doi:10.1109/mci.2006.1597059

Coghlan, D., & Brannick, T. (2005). *Doing action research in your own organization* (2nd ed.). SAGE Publications.

Coughlan, P., & Coghlan, D. (2002). Action research for operations management. *International Journal of Operations & Production Management, 22*(2), 220-240. doi:10.1108/01443570210417515

Coughlan, P., & Coghlan, D. (2009). Action research. In C. Karlsson (Ed.), *Research Methods for Operations Management* (2nd ed., pp. 233-267). Routledge.

Curatolo, N., Lamouri, S., Huet, J.-C., & Rieutord, A. (2014). A critical analysis of lean approach structuring in hospitals. *Business Process Management Journal, 20*(3), 433-454. doi:10.1108/bpmj-04-2013-0051

Dresch, A., Veit, D. R., Lima, P. N., Lacerda, D. P., & Collatto, D. C. (2019). Inducing Brazilian manufacturing SMEs productivity with lean tools. *International Journal of Productivity and Performance Management, 68*(1), 69-87. doi:10.1108/ijppm-10-2017-0248

Drohomeretski, E., Costa, S. E. G., Lima, E. P., & Garbuio, P. A. R. (2014). Lean, Six Sigma and Lean Six Sigma: An analysis based on operations strategy. *International Journal of Production Research, 52*(3), 804-824. doi:10.1080/00207543.2013.842015

Drucker, P. (2006). *The effective executive: The definitive guide to getting the right things done* (3rd ed.). HarperCollins Publishers.

Fairbanks, C. B. (2007). Using six sigma and lean methodologies to improve OR throughput. *AORN Journal, 86*(1), 73-82. doi:10.1016/j.aorn.2007.06.011

Garcia-Garcia, G., Singh, Y., & Jagtap, S. (2022). Optimising changeover through lean-manufacturing principles: A case study in a food factory. *Sustainability, 14*(14), 8279. doi:10.3390/su14148279

Gaspar, F., & Leal, F. (2020). A methodology for applying the shop floor management method for sustaining lean manufacturing tools and philosophies: A study of an automotive company in Brazil. *International Journal of Lean Six Sigma, 11*(6), 1219-1238. doi:10.1108/ijlss-09-2019-0098

Gazova, A., Papulova, Z., & Papula, J. (2016). The application of concepts and methods based on process approach to increase business process efficiency. *Procedia Economics and Finance, 39*, 197-205. doi:10.1016/s2212-5671(16)30284-2

Grond, M. O. W., Luong, N. H., Morren, J., & Slootweg, J. G. (2012). Multi-objective optimization techniques and applications in electric power systems. *2012 47th International Universities Power Engineering Conference (UPEC)*, 1-6. doi:10.1109/upec.2012.6398417

Gupta, S., & Jain, S. K. (2015). An application of 5S concept to organize the workplace at a scientific instruments manufacturing company. *International Journal of Lean Six Sigma, 6*(1), 73-88. doi:10.1108/ijlss-08-2013-0047

Gupta, S., Sharma, M., & Sunder, V. (2016). Lean services: A systematic review. *International Journal of Productivity and Performance Management, 65*(8), 1025-1056. doi:10.1108/IJPPM-02-2015-0032

Gupta, V., Jain, R., Meena, M. L., & Dangayach, G. S. (2018). Six-sigma application in tire-manufacturing company: A case study. *Journal of Industrial Engineering International, 14*(3), 511-520. doi:10.1007/s40092-017-0234-6

Guzman-Moratto, H., Uribe-Martes, C., & Neira-Rodado, D. (2022). Improving productivity using simulation: Case study of a mattress manufacturing process. *Procedia Computer Science, 198*, 650-655. doi:10.1016/j.procs.2021.12.301

Harmon, P. (2014). *Business process change: A business process management guide for managers and process professionals* (3rd ed.). San Francisco, California, USA: Morgan Kaufmann.

Improta, G., Ricciardi, C., Borrelli, A., D'alessandro, A., Verdoliva, C., & Cesarelli, M. (2020). The application of six sigma to reduce the pre-operative length of hospital stay at the hospital Antonio Cardarelli. *International Journal of Lean Six Sigma, 11*(3), 555-576. doi:10.1108/ijlss-02-2019-0014

Improta, G., Romano, M., Cicco, M. V. D., Ferraro, A., Borrelli, A., Verdoliva, C., Triassi, M., & Cesarelli, M. (2018). Lean thinking to improve emergency department throughput at AORN Cardarelli hospital. *BMC Health Services Research, 18*(914), 1-9. doi:10.1186/s12913-018-3654-0

Ivankova, N., & Wingo, N. (2018). Applying mixed methods in action research: Methodological potentials and advantages. *American Behavioral Scientist, 62*(7), 978-997. doi:10.1177/0002764218772673

Jahangirian, M., Eldabi, T., Naseer, A., Stergioulas, L. K., & Young, T. (2010). Simulation in manufacturing and business: A review. *European Journal of Operational Research, 203*(1), 1-13. doi:10.1016/j.ejor.2009.06.004

Jimenez, G., Santos, G., Sá, J. C., Ricardo, S., Pulido, J., Pizarro, A., & Hernández, H. (2019). Improvement of productivity and quality in the value chain through lean manufacturing – A case study. *Procedia Manufacturing, 41*, 882-889. doi:10.1016/j.promfg.2019.10.011

Kennedy, I., Plunkett, A., & Haider, J. (2013). Implementation of lean principles in a food manufacturing company. In A. Azevedo (Ed.), *Advances in Sustainable and Competitive Manufacturing Systems* (pp. 1579-1590). Springer International Publishing. doi:10.1007/978-3-319-00557-7_127

Kock, N., Danesh, A., & Komiak, P. (2008). A discussion and test of a communication flow optimization approach for business process redesign. *Knowledge and Process Management, 15*(1), 72-85. doi:10.1002/kpm.301

Kumar, S., & Harms, R. (2004). Improving business processes for increased operational efficiency: A case study. *Journal of Manufacturing Technology Management, 15*(7), 662-674. doi:10.1108/17410380410555907

Kumar, S., Dhingra, A., & Singh, B. (2018). Lean-kaizen implementation: A roadmap for identifying continuous improvement opportunities in Indian small and medium sized enterprise. *Journal of Engineering, Design and Technology, 16*(1), 143-160. doi:10.1108/JEDT-08-2017-0083

Lee, D., Rho, B.-H., & Yoon, S. N. (2015). Effect of investments in manufacturing practices on process efficiency and organizational performance. *International Journal of Production Economics, 162*, 45-54. doi:10.1016/j.ijpe.2015.01.001

Maalouf, M., & Zaduminska, M. (2019). A case study of VSM and SMED in the food processing industry. *Management and Production Engineering Review, 10*(2), 60-68. doi:10.24425/mper.2019.129569

Mansar, S. L., & Reijers, H. A. (2007). Best practices in business process redesign: Use and impact. *Business Process Management Journal, 13*(2), 193-213. doi:10.1108/14637150710740455

Mazelan, A. H., Ali, S. A. S., & Huda, M. S. S. (2021). Improving performance and process in food manufacturing industry using lean engineering principles. In M. S. Bahari, A. Harun, Z. Z. Abidin, R. Hamidon, & S. Zakaria (Eds.), *Intelligent Manufacturing and Mechatronics* (pp. 1307-1315). Springer International Publishing. doi:10.1007/978-981-16-0866-7_116

Mehdouani, K., Missaoui, N., & Ghannouchi, S. A. (2019). An approach for business process improvement based on simulation technique. *Procedia Computer Science, 164*, pp. 225-232. doi:10.1016/j.procs.2019.12.176

Mukherjee, I., & Ray, P. K. (2006). A review of optimization techniques in metal cutting processes. *Computers & Industrial Engineering, 50*(1-2), 15-34. doi:10.1016/j.cie.2005.10.001

Murugaiah, U., Benjamin, S. J., Marathamuthu, M. S., & Muthaiyah, S. (2010). Scrap loss reduction using the 5-whys analysis. *International Journal of Quality & Reliability Management, 27*(5), 527-540. doi:10.1108/02656711011043517

Navalertporn, T., & Afzulpurkar, N. V. (2011). Optimization of tile manufacturing process using particle swarm optimization. *Swarm and Evolutionary Computation, 1*(2), 97-109. doi:10.1016/j.swevo.2011.05.003

Ng, K. K. H., Chen, C.-H., Lee, C. K. M., Jiao, J., & Yang, Z.-X. (2021). A systematic literature review on intelligent automation: Aligning concepts from theory, practice, and future perspectives. *Advanced Engineering Informatics*, 101246. doi:10.1016/j.aei.2021.101246

Parry, G. C., & Turner, C. E. (2006). Application of lean visual process management tools. *Production Planning & Control, 17*(1), 77-86. doi:10.1080/09537280500414991

Purushothaman, M., Seadon, J., & Moore, D. (2020). Waste reduction using lean tools in a multicultural environment. *Journal of Cleaner Production, 265*, 121681. doi:10.1016/j.jclepro.2020.121681

Radeschütz, S., Schwarz, H., & Niedermann, F. (2015). Business impact analysis – A framework for a comprehensive analysis and optimization of business processes. *Computer Science – Research and Development, 30*, 69-86. doi:10.1007/s00450-013-0247-3

Randhawa, J. S., & Ahuja, I. S. (2017). 5S – a quality improvement tool for sustainable performance: Literature review and directions. *International Journal of Quality & Reliability Management, 34*(3), 334-361. doi:10.1108/ijqrm-03-2015-0045

Rao, S. S. (2009). Introduction to optimization. In *Engineering optimization: Theory and practice* (4th ed., pp. 1-62). John Wiley & Sons.

Realyvásquez-Vargas, A., Flor-Moltalvo, F. J., Blanco-Fernández, J., Sandoval-Quintanilla, J. D., Jiménez-Macías, E., & García-Alcaraz, J. L. (2019). Implementation of production process standardization – A case study of a publishing company from the SMEs sector. *Processes, 7*(10), 646. doi:10.3390/pr7100646

Régis, T. K. O., Santos, L. C., & Gohr, C. F. (2019). A case-based methodology for lean implementation in hospital operations. *Journal of Health Organization and Management, 33*(6), 656-676. doi:10.1108/JHOM-09-2018-0267

Reijers, H. A., & Mansar, S. L. (2005). Best practices in business process redesign: An overview and qualitative evaluation of successful redesign heuristics. *Omega, 33*(4), 283-306. doi:10.1016/j.omega.2004.04.012

Sá, J. C., Vaz, S., Carvalho, O., Lima, V., Morgado, L., Fonseca, L., Doiro, M., & Santos, G. (2022). A model of integration ISO 9001 with Lean six sigma and main benefits achieved. *Total Quality Management & Business Excellence, 33*(1-2), 218-242. doi:10.1080/14783363.2020.1829969

Saunders, M., Lewis, P., & Thornhill, A. (2016). *Research methods for business students* (7th ed.). Pearson Education Limited.

Siha, S. M., & Saad, G. H. (2008). Business process improvement: Empirical assessment and extensions. *Business Process Management Journal, 14*(6), 778-802. doi:10.1108/14637150810915973

Singh, B., & Sharma, S. K. (2009). Value stream mapping as a versatile tool for lean implementation: An Indian case study of a manufacturing firm. *Measuring Business Excellence, 13*(3), 58-68. doi:10.1108/13683040910984338

Singh, J., Singh, H., & Singh, I. (2018). SMED for quick changeover in manufacturing industry – A case study. *Benchmarking: An International Journal, 25*(7), 2065-2088. doi:10.1108/bij-05-2017-0122

Somphanpae, S., & Boonsiri, S. (2016). Business process improvement using adjustable parameters on simulation – A case study in restaurant business. *Journal of Advances in Information Technology, 7*(4), 232-238. doi:10.12720/jait.7.4.232-238

Suárez-Barraza, M. F., & Rodríguez-González, F. G. (2019). Cornerstone root causes through the analysis of the Ishikawa diagram, is it possible to find them? A first research approach. *International Journal of Quality and Service Sciences, 11*(2), 302-316. doi:10.1108/ijqss-12-2017-0113

Sutharsan, S. M., Prasad, M. M., & Vijay, S. (2020). Productivity enhancement and waste management through lean philosophy in Indian manufacturing industry. *Materials Today: Proceedings, 33*(7), 2981-2985. doi:10.1016/j.matpr.2020.02.976

Tayal, A., & Kalsi, N. S. (2021). Review on effectiveness improvement by application of the lean tool in an industry. *Materials Today: Proceedings, 43*(2), 1983-1991. doi:10.1016/j.matpr.2020.11.431

Ulhassan, W., Schwarz, U. T., Westerlund, H., Sandahl, C., & Thor, J. (2015). How visual management for continuous improvement might guide and affect hospital staff: A case study. *Quality Management in Health Care, 24*(4), 222-228. doi:10.1097/qmh.0000000000000073

Vamsi, N. K. J., & Sharma, A. (2014). Lean manufacturing implementation using value stream mapping as a tool. *International Journal of Lean Six Sigma, 5*(1), 89-116. doi:10.1108/ijlss-04-2012-0002

Vanwersch, R. J. B., Shahzad, K., Vanderfeesten, I., Vanhaecht, K., Grefen, P., Pintelon, L., Mendling, J., Merode, G. G., & Reijers, H. A. (2016). A critical evaluation and framework of business process improvement methods. *Business & Information Systems Engineering, 58*(1), 43-53. doi:10.1007/s12599-015-0417-x

Vergidis, K., Saxena, D., & Tiwari, A. (2012). An evolutionary multi-objective framework for business process optimisation. *Applied Soft Computing, 12*(8), 2638-2653. doi:10.1016/j.asoc.2012.04.009

Vergidis, K., Tiwari, A., & Majeed, B. (2008). Business process analysis and optimization: Beyond reengineering. *IEEE Transactions on Systems, Man, and Cybernetics, Part C (Applications and Reviews), 38*(1), 69-82. doi:10.1109/tsmcc.2007.905812

Vincent, N. E., Igou, A., & Burns, M. B. (2020). Preparing for the robots: A proposed course in robotic process automation. *Journal of Emerging Technologies in Accounting, 17*(2), 75-91. doi:10.2308/jeta-2020-020

Widodo, S. M., Astanti, R. D., Ai, T. J., & Samadhi, T. M. A. A. (2021). Seven-waste framework of waste identification and elimination for computer-based administrative work. *The TQM Journal, 33*(4), 773-803. doi:10.1108/tqm-04-2020-0072

Zahrotun, N., & Taufiq, I. (2018). Lean manufacturing: Waste reduction using value stream mapping. *E3S Web of Conferences, 73*, 1-6. doi:10.1051/e3sconf/20187307010

Zellner, G. (2011). A structured evaluation of business process improvement approaches. *Business Process Management Journal, 17*(2), 203-237. doi:10.1108/14637151111122329

APPENDIX

Appendix A – Diagnosis Phase Questionnaires

COMMUNICATION WITH THE MAINTENANCE TEAM

* Required

1. **Consider the time you have to wait for technical support in case of a malfunction. How do you rate this time?** *
   Very Long ___ Long ___ Normal ___ Fast ___ Very Fast ___
2. **Now consider the time it takes to reach the contact person who can provide you with technical support. How do you rate that time?** *
   Very Long ___ Long ___ Normal ___ Fast ___ Very Fast ___
3. **If you think the waiting time could be shorter, what reasons do you find for the delay?** *
   Physical Distance ___
   Lack of Communication Equipment on the Line ___
   Lack of availability of technicians ___
   Other: _____

Appendix A.1. Diagnosis phase questionnaire on communication with the maintenance team

EQUIPMENT IDENTIFICATION

* Required

1. **Have you ever pressed a wrong button because it was not properly labelled?** *
   Disagree ___ Neither Agree Nor Disagree ___ Agree ___
2. **Do you find it difficult to understand the functions of the buttons?** *
   Disagree ___ Neither Agree Nor Disagree ___ Agree ___
3. **If you selected *"Agree"*, what are the reasons that make it difficult for you to understand the functionality of the buttons?**
   No Identification ___
   Wrong Identification ___
   Wear of Identification (E.g. Cleaning) ___
   Other: _____
4. **Have you ever felt the need to ask colleagues for help in making decisions regarding the selection of equipment options?** *
   Disagree ___ Neither Agree Nor Disagree ___ Agree ___
5. **If you recently started working on this production line, do you think you would easily and autonomously understand the functionalities of the buttons on the devices?** *
   Disagree ___ Neither Agree Nor Disagree ___ Agree ___
6. **If you selected the *"Disagree"* option, why do you think you would have that difficulty?**
   _____

Appendix A.2. Diagnosis phase questionnaire on equipment identification

DOCUMENTATION

* Required

1. **How often do you use the documents in the office to help you make decisions or clarify issues? ***
   Every day ___ Once a week ___ Fortnightly ___ Once a month ___ Rarely ___ Never ___

2. **If you selected the option "*Rarely*" or *"Never"*, why don't you use the files more often?**
   Disorganised Documents ___
   Outdated Documents ___
   Wear and Tear of Documents ___
   No Need ___
   Other: _____

3. **How do you evaluate the process of searching for the files you want? ***
   Very Difficult ___ Difficult ___ Normal ___ Easy ___ Very Easy ___

4. **If you think that the time taken to search for documents could be shorter, what are the reasons for the delay? ***
   Disorganised Documents ___
   Outdated Documents ___
   Other: _____

5. **In your opinion do you think that at the moment there are obsolete documents, for example, manuals relating to equipment that does not currently exist in the factory? ***
   Disagree ___ Neither Agree Nor Disagree ___ Agree ___

6. **If you selected the *"Agree"* option, which documents do you identify as obsolete?**
   _____

Appendix A.3. Diagnosis phase questionnaire on documentation

Appendix B – Pareto Chart

Category	Cakes	Kgs	Kgs/h	Frequency	% Frequency	% Frequency Cumulative	% per Category	% per Category Cumulative
Misshapen	1559	97.81166	4.156302833	0.225452332	23%	23%	8%	8%
Large	990	73.7946	3.135747875	0.170093879	17%	40%	8%	15%
Glued	909	57.03066	2.42339915	0.131453605	13%	53%	8%	23%
Uncooked	873	54.77202	2.327422946	0.126247521	13%	65%	8%	31%
Cut	763	47.87062	2.034162323	0.110340044	11%	76%	8%	38%
With Particles	705	44.2317	1.879533994	0.101952466	10%	87%	8%	46%
Stained	308	19.32392	0.821129745	0.044540935	4%	91%	8%	54%
Small	354	18.18144	0.772582436	0.04190756	4%	95%	8%	62%
Crumpled	272	17.06528	0.725153541	0.039334852	4%	99%	8%	69%
Burnt	37	2.32138	0.09864221	0.005350697	1%	100%	8%	77%
Without Coverage	18	1.12932	0.047988102	0.002603042	0%	100%	8%	85%
Broken	3	0.18822	0.007998017	0.00043384	0%	100%	8%	92%
Without Consistency	2	0.12548	0.005332011	0.000289227	0%	100%	8%	100%
TOTAL	**6793**	**433.8463**	**18.43539518**					

Appendix B.1. Data used to create the Pareto chart

Appendix C – Action Planning Phase Questionnaires

COMMUNICATION WITH THE MAINTENANCE TEAM

* Required

1. **Do you think it would be beneficial to have a radio on the production line?** *
   Disagree ___ Neither Agree Nor Disagree ___ Agree ___
2. **If you selected the option *"Agree"* or "*Neither Agree Nor Disagree*", in what sense do you think it would improve?**
   Less time removing cake (Rework) ___
   Less time looking for assistance (Tiredness) ___
   Other: _____
3. **Do you find other solutions that could solve this problem?** *
   Disagree ___ Neither Agree Nor Disagree ___ Agree ___
4. **If you selected the *"Agree"* option, what other solutions do you have?**
   _____

Appendix C.1. Action planning phase questionnaire on communication with the maintenance team

EQUIPMENT IDENTIFICATION

* Required

1. **Do you think that if the identification labels were updated the process of decision making would be easier, faster and error-free?** *
   Disagree ___ Neither Agree Nor Disagree ___ Agree ___
2. **Do you find other solutions that could facilitate the identification?** *
   Disagree ___ Neither Agree Nor Disagree ___ Agree ___
3. **If you selected the *"Agree"* option, what other solutions do you have?**
   _____

Appendix C.2. Action planning phase questionnaire on equipment identification

DOCUMENTATION

* Required

1. **Do you find any solutions to facilitate the process of searching for documents?** *
   Disagree ___ Neither Agree Nor Disagree ___ Agree ___
2. **If you selected the *"Agree"* option, what are the solutions?**
   _____
3. **Do you think that if the documents were organised by colour system for each of the lines and by numbers, with an index, it would make it easier to find them?** *
   Disagree ___ Neither Agree Nor Disagree ___ Agree ___
4. **If you selected the *"Disagree"* option, do you have any other suggestions?**
   _____

Appendix C.3. Action planning phase questionnaire on documentation

Appendix D – Implementation Phase of Inefficiency Solutions[3]



Appendix D.1. Radio installation on the production line

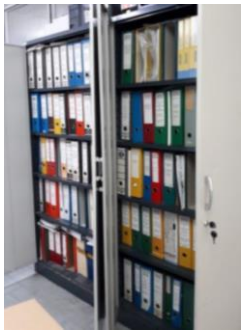


Appendix D.2. Replacement with new labels



Appendix D.3. Obsolete documents

[3] Due to the fact that the figures contain confidential information, to illustrate some of the improvements made, it was required to slightly blur the pictures.



Initial situation



Document registration



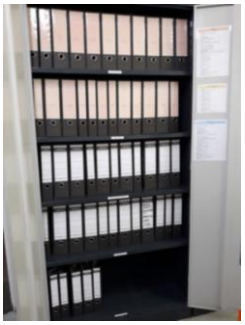
Organisation by line and by area



Cleaning



Files Replacement



Files Identification





Documents organised per line and per area with colour system and index

Appendix D.4. Implementation of 5S for document organisation

Appendix E – Implementation Phase of Ineffectiveness Solutions[4]

COMPANY B

Production Line: X
Machine/Area: Cutters
TITLE: Handling of Cutters in the Cleaning Process

Edition Nº 1
Created by: Maria Inês Machado
Date: May 2022

1. Remove the cutters and place them in the corresponding cleaning trolley.
2. In the washroom, place the white plate that has the fittings for the cutters on top of the bench with grill.
3. Disassemble each cutter and place the pieces correctly into the white plate fitting, corresponding to the size of the piece.
4. With warm water, rinse the cutters with the pressure hose.
5. After a brief rinse, clean the cutters individually, always in fitting position or upside down, **NEVER** lay the cutters on their sides to avoid damaging the material.
6. After ensuring that all the pieces are free of residues and dough, assemble each of the cutters and place them in its cleaning trolley, which has also been previously washed to remove any residues and dough.
7. Then place the cutters in the materials room covered with plastic to prevent soiling and contamination.

STEP 1: Remove the cutters and place them in the trolley.



STEP 2: Place the white plate on the worktop.



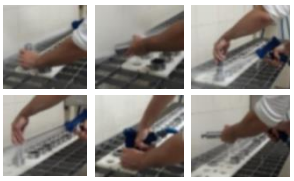
STEP 3: Disassemble the cutters and fit them to the plate.



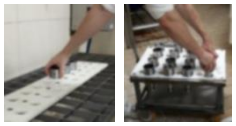
STEP 4: Rinse all cutters with warm water.



STEP 5: Carefully and correctly clean each piece of the cutters.



STEP 6: Assemble each cutter and place them in the trolley.



STEP 7: Place the car with the cutters covered in the materials room.



ANTI-FAILURE SYSTEM PROTOCOL

1ST STEP: Check the correct positioning of the cutters on the white plate.



2ND STEP: Carefully clean each part of the cutters with warm water.



3RD **STEP:** Assemble the cutters and place them in a safe area.



Appendix E.1. Work instruction on the correct handling of the cutters in the cleaning process

COMPANY B

Production Line: X
Machine/Area: Cutters

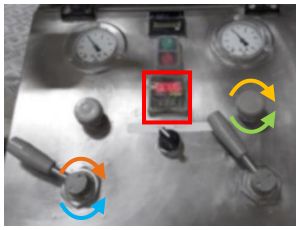
OPL – One Point Lesson
TITLE: Cutter Pressure Regulation

Edition Nº 1
Created by: Maria Inês Machado
Date: May 2022

Basic Knowledge [X] Safety [ ] Cleaning [ ] Improvement [ ]

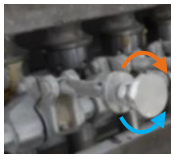
Cutter Control Panel

Size	- **All** large cakes → Turn pressure regulator counter-clockwise - **All** small cakes → Turn pressure regulator clockwise
Shelf Position	- Higher panel value → Cake further back on the shelf - Lower panel value → Cake further forward on the shelf
Cutter Bowl	- Opening the cutter bowl → Turn lever clockwise - Closing the cutter bowl → Turn lever counter-clockwise



Individual Cutter Mechanism

Individual Size	- Small / low cake → Turn the handle of the cutter clockwise - Large / high cake → Turn the handle of the cutter counter-clockwise



Appendix E.2. Work instruction on cutter pressure regulation

[4] Due to the fact that the figures contain confidential information, to illustrate some of the improvements made, it was required to slightly blur the pictures.

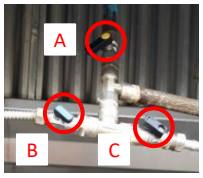
COMPANY B

Production Line: X
Machine/Area: Fryer
TITLE: Preparation and Adjustment of the Fryer Turner

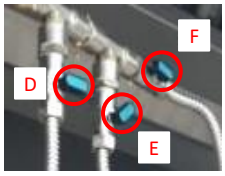
Edition Nº 1
Created by: Maria Inês Machado
Date: May 2022

1. In case of using the fryer, open the general air valve (**A**).
2. Reposition the cake in relation to the rod located on the side of the fryer by adjusting the air valves **B** and **C**.
3. Also adjust the advance of the cake as it approaches the turner through the air valve **D**.
4. Check if the grey piece, which is highlighted, is slightly covered by the oil in the fryer.
5. If the grey piece is not submersed in oil, adjust the turner on the fryer by rotating the knob counter-clockwise so that the piece moves downwards.
6. If the grey piece is excessively submerged, adjust the turner on the fryer by rotating the knob clockwise so that the piece moves upwards.

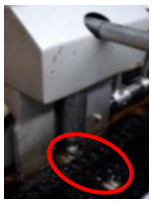
STEP 1 and 2: Connect and adjust the air valves.



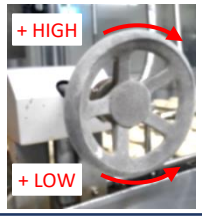
STEP 3: Adjust the air valve D.



STEP 4: Confirm the position of the grey piece.



STEP 5 and 6: Adjust the turner on the fryer.



ANTI-FAILURE SYSTEM PROTOCOL

1ST STEP: Check if the air valves are open.



2ND STEP: Adjust air valves.



3RD **STEP:** Position the fryer turner correctly according to the oil level.



Appendix E.3. Work instruction on preparing and adjusting the fryer turner






Appendix E.4. Replacement of the fermentation chamber chain

COMMUNICATION WITH THE MAINTENANCE TEAM

* Required

1. **How satisfied are you with the implementation of the radio on the production line?** *
   Very Dissatisfied ___
   Dissatisfied ___
   Neither Satisfied Nor Dissatisfied ___
   Satisfied ___
   Very Satisfied ___

2. **Have you used the radio since its implementation?** *
   No ___
   No, but I have seen it being used ___
   Yes ___

3. **If you selected the option *"Yes"* or *"No, but I have seen it being used"*, how do you rate the experience?**
   Very Poor ___
   Poor ___
   Normal ___
   Good ___
   Very Good ___

4. **Do you think the radio has improved communication with maintenance and reduced waiting times?** *
   Disagree ___ Neither Agree Nor Disagree ___ Agree ___

5. **Do you have any other suggestions to improve communication with maintenance technicians and reduce waiting times?** *
   Disagree ___ Neither Agree Nor Disagree ___ Agree ___

6. **If you selected the *"Agree"* option, what suggestions do you have?**
   _____

Appendix F.1. Evaluation phase questionnaire on communication with the maintenance team

EQUIPMENT IDENTIFICATION

* Required

1. **How satisfied are you with the implementation of the new identification labels on the equipment? ***
   Very Dissatisfied ___
   Dissatisfied ___
   Neither Satisfied Nor Dissatisfied ___
   Satisfied ___
   Very Satisfied ___

2. **Do you think that with this implementation, the process of deciding which buttons to select is faster, easier and error-free? ***
   Disagree ___ Neither Agree Nor Disagree ___ Agree ___

3. **Do you think that this implementation allows you to facilitate your work and at the same time help new line operators in the learning process? ***
   Disagree ___ Neither Agree Nor Disagree ___ Agree ___

4. **Do you have any suggestions to make the process even more intuitive and faster? ***
   Disagree ___ Neither Agree Nor Disagree ___ Agree ___

5. **If you selected the *"Agree"* option, what suggestions do you have?**
   _____

Appendix F.2. Evaluation phase questionnaire on equipment identification

DOCUMENTATION

* Required

1. **How satisfied are you with the new format for organising the files? ***
   Very Dissatisfied ___
   Dissatisfied ___
   Neither Satisfied Nor Dissatisfied ___
   Satisfied ___
   Very Satisfied ___

2. **How do you evaluate the process of finding the files you want with the new organisation format implemented? ***
   Very Long ___
   Long ___
   Normal ___
   Fast ___
   Very Fast ___

3. **Do you think the new file organisation format is intuitive and easy to understand for everyone? ***
   Disagree ___ Neither Agree Nor Disagree ___ Agree ___

4. **Do you have any other suggestions to make the process of searching for files even quicker and easier? ***
   Disagree ___ Neither Agree Nor Disagree ___ Agree ___

5. **If you selected the *"Agree"* option, what are your suggestions?**
   _____

Appendix F.3. Evaluation phase questionnaire on documentation

Appendix G – Percentages of Occurrence by Defect Category

FREQUENCY	CATEGORY	BEFORE (%)	AFTER (%)	Δ (%)
1º	Misshapen	22.55%	12.82%	-9.72%
2º	Large	17.01%	11.94%	-5.07%
3º	Glued	13.15%	5.22%	-7.93%
4º	Uncooked	12.62%	8.24%	-4.38%
5º	Cut	11.03%	15.40%	4.37%
6º	With Particles	10.20%	23.51%	13.31%
7º	Stained	4.45%	10.99%	6.54%
8º	Small	4.19%	8.13%	3.94%
9º	Crumpled	3.93%	2.72%	-1.21%
10º	Burnt	0.54%	0.08%	-0.45%
11º	Without Coverage	0.26%	0.53%	0.27%
12º	Broken	0.04%	0.06%	0.01%
13º	Without Consistency	0.03%	0.36%	0.33%

Appendix G.1. Comparison of the percentages of occurrence before and after the interventions per defect category