Hungarian University of Agricultural and Life Sciences

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Supply Chain Management Programme

TITLE OF THE DISSERTATION

Implementing Lean Manufacturing tools in a semi preserved fish production unit to optimize production and eliminate all forms of waste.

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ABREVIATIONS LIST

MRT: Minimum Repeatable Time

EEC: European Economic Committee

VSM: Value stream mapping

OEE: Overall equipment effectiveness

DH: Moroccan Dirham

SMED: Single-Minute Exchange of Die

PDCA: Plan, Do, Check, Act

5S: Sort, Straighten, Shine, Standardize, and Sustain

EEC: European Economic Committee

BRC: British Retail Consortium

IFS: International Food Standard certifications

5W1H: What, Who, Where, When, Why and How

DMAIC: Define, Measure, Analyze, Improve, and Control

FMECA: Failure modes, effects, and criticality analysis

JIT: Just In Time

RDI: Electronic data interchange

Nk: number of Kanbans

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INTRODUCTION

The industry of semi-canning is centered on the processing of marinades for fisheries products and anchovies. 34 production facilities, the majority of which are in Agadir, make up this industry. It has a workforce of about 8000 and a daily production capacity of about 240 tons (1). The export revenue for this sector was DH 1.2 billion in 2012. 85% of these exports are going to the market in the European Union (1).

For businesses in the semi-canning sector, the key issue is to lower production costs and non-quality while providing a product with the best price-to-quality ratio available. But one of the most crucial things that businesses must concentrate on to attain these goals is enhancing the overall return on investment through tracking waste. Our thesis is being tested in the UNIMER company within this context. It aims to minimize all forms of waste generated within the production process.

To achieve the overall rate of return targeted by UNIMER management, it is necessary to improve production performance by eliminating waste in terms of time, material and unnecessary movements. It is in this context that the production manager has proposed a topic through which we must map losses. Then, we will do an analysis of the causes to provide elements of solutions and put them in place.

This report is divided into four main parts. The first chapter aims to appraise the general framework of this work by first presenting the company UNIMER. Then we will present the general context of the project, its approach, and its plan.

Through the second chapter, we will describe the production process. Then analyze the level of production performance by calculating the various indicators. We will present a survey of the situation by mapping the value flows (VSM). The analysis of this data will allow to evaluate the time lost due to waste and to focus on the major causes on which efforts will be focused.

The problems identified by the existing analysis will clarify several areas for improvement likely to optimize flows and improve productivity in threading and packaging workshops. These improvements will be the subject of four separate projects. The first is dedicated to the deployment of a project (SMED) for the optimization of serial change operations. The second is devoted to the problem-solving method. The third relates to the implementation of the "5S"

program, which aims to enhance the organizational standards in the maintenance workshop. The establishment of the Kanban system and the uniformity of work toward the finish are the objectives of the fourth chapter.

The objectives of this project are:

1. Determine the value chain and identify waste.
2. Determine the time required to complete a step in the production process.
3. Study of the current state of performance and its evolution.
4. Modelling the process and identifying non-value added and unnecessary movements in the chain.
5. Reduce changeover times on the sealing machine.
6. Reorganization of the maintenance area.
7. Resolution of problems observed by the company (high rate of co-products).

During this process we will use many methods and tools such as:

- VSM Maps
- Brainstorming
- 5 W1H
- DMAIC
- GANTT Chart
- Pareto Diagram
- Follow-up sheets
- key performance indicators
- Ishikawa Diagram
- Pareto Diagram
- Ishikawa
- 5S checklist
- Kaizen
- Visual management
- Dashboard

1 Context of the project: Host institution presentation and Description of production process.

1.1 Introduction:

This first chapter gives a broad overview of the environment in which our final-year project was carried out in UNIMER company. A presentation of the host organization as well as the context of our thesis will be given. In order to determine the problem at hand, the specification detailing the project's goals and the project scheduling was created.

1.2 Presentation of the host organization:

UNIMER CNA3 is a Moroccan group of companies founded in 1988 that operates in the maritime fishing sector by producing marinades of anchovies and sardines in refrigerated or frozen form. UNIMER's products are mostly destined for export, primarily to the European Economic Committee (EEC). The daily production capacity of UNIMER CNA3 is approximately 80,000 cans of preserves. The cannery receives an approximate quantity of 65 tons of fish (mackerel and sardines), coming from the different Moroccan coasts from the southern Atlantic coast of Morocco. Where fish is abundant. (Rapport-Financier-Unimer-2020-v3.Pdf, n.d.)

UNIMER CNA3 exports the majority of its production, i.e. 99%. Among his destinations are account: England, the United States, Italy, Germany, France, Belgium, Switzerland,Austria, Hungary, Chile, the Middle East and some African countries.

1.2.1 Activity Sector:

The activity of semi-conservation in Morocco is mostly based on the transformation of the anchovy, as well as sardine and other fish that require a qualified female hand. 5000 people are employed in 33 units spread around the country, they guarantee a production of around 16.000 tons and generate a revenue of approximately 911 million dirhams, almost entirely from exports. With a diverse product portfolio, Morocco meets 44% of the needs of the American market in semi-conserved anchovy and directs 90% of its production to European Union markets (EU).

The following (Figure 1) represent UNIMER's product sales map with a diverse product portfolio:

Figure 1: UNIMER Product sales map (UNIMER, 2023)

1.2.2 Company fact sheet:

Table 1: Company fact sheet (UNIMER, 2023)

Company name	**UNIMER CNA3**
Address	15, Rue Jabal Saghrou – CIL – Casablanca-Morocco
Number of employees	5000
Production capacity	120 000 Tons per year
Creation date	1988
Investment amount	15.000.000 DH
Turnover	20.000.000 (2021)
Activity	Anchovies and sardines marinated in vinegar stored chilled or frozen.
Packaging	Buckets, trays and blocks
Target market	National and International
Approval	6225
Telephone	+212522791480
Email	info@unimer.com
Website	www.unimergroup.com

1.2.3 Certifications:

The company UNIMER certified BRC v 7, IFS v 6, EFSIS, Friends of the Sea, OR, MSC, and HALAL certificates. The BRC and IFS standards are audit standards set up by large retailers to allow the delegation of their suppliers to third-party organizations in order to ensure control of food safety and monitor the quality level. manufacturers of Private Label products and/or first price products.

These two standards were created in order to:

- Provide healthy products to the consumer.
- Ensure the safety of food at the distributor.
- Meet the requirements of EU hygiene regulations.

figure 2: UNIMER certificates (UNIMER, 2023)

1.2.4 Organizational chart:

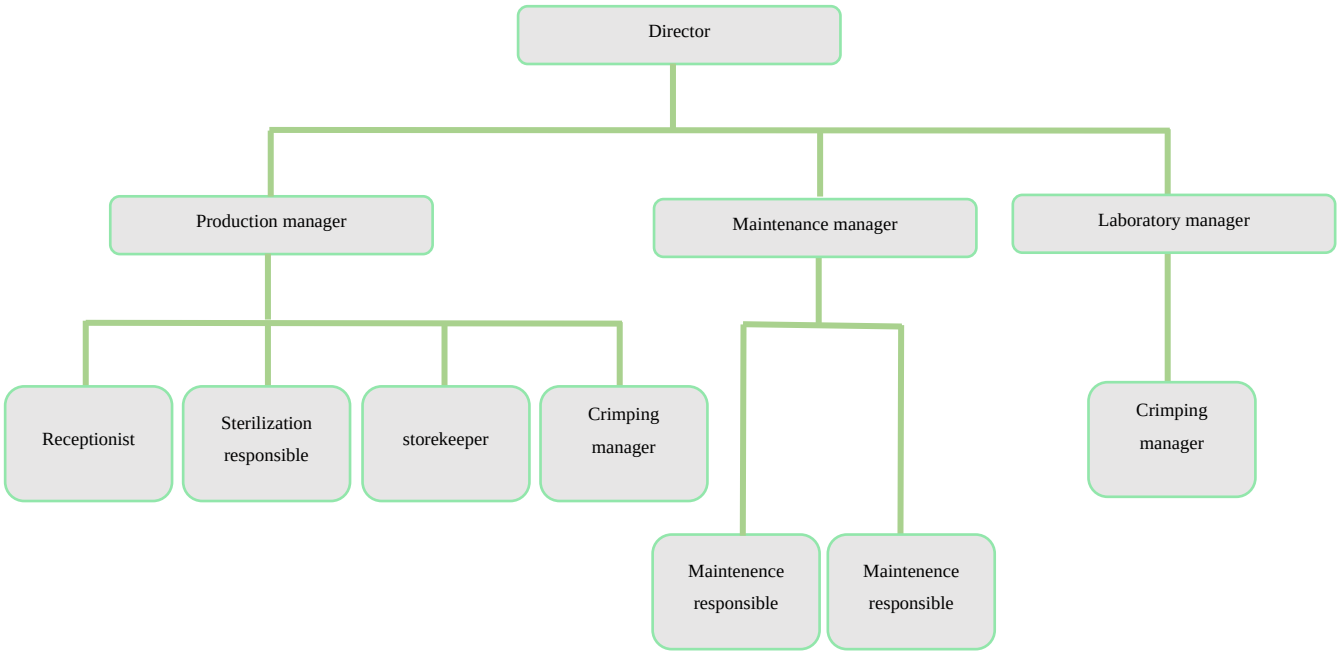


Figure 3: UNIMER Organizational chart (UNIMER, 2023)

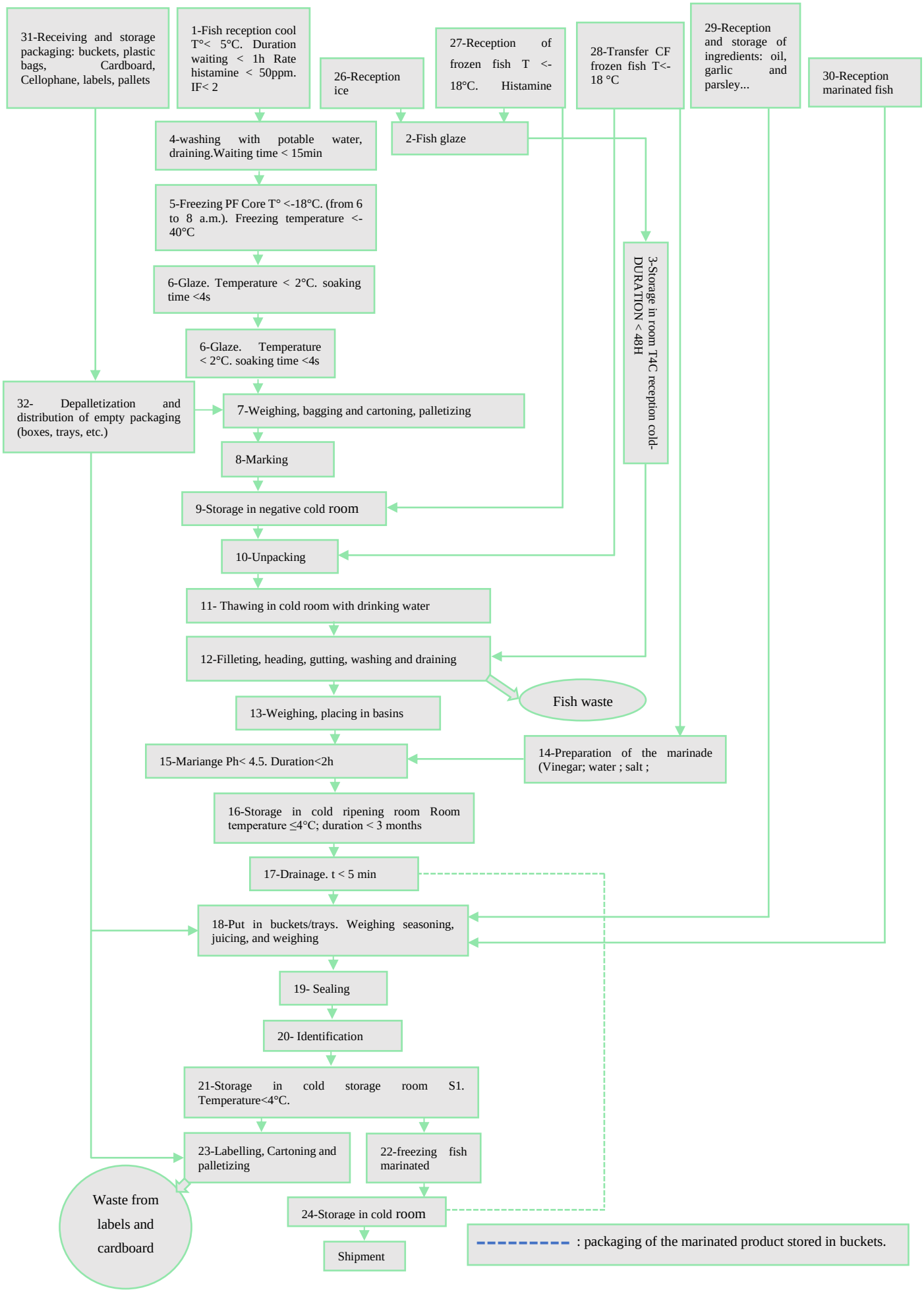
1.2.5 Product Range & Manufacturing Diagram:

The (Table 2) below contains the product range of the UNIMER company

Table 2: Unimer Product Range (UNIMER, 2023)

Vanelli	Belmonte Gourmet	The Monegasque	Fiorito
			
Titus	**Sardine**	**The Monegasque**	**Madrigal**
			

Table 3: Manufacturing Diagram (UNIMER, 2023)



1.2.6 Description of production process:

The following steps represent the production process:

- **Reception of fresh fish:**

The iced fish arrived at the factory in refrigerated or insulated trucks in plastic food crates.

- **Fish glaze:**

The fish is sprinkled with ice upon receipt in case of immediate processing (filleting, gutting).

- **Storage in the receiving cold room:**

All the fish crates are transferred to the reception cold room after icing.

- **reezing fresh fish:**

The crates are then transferred to the freezing tunnels for freezing at a temperature < – 40°C.

- **glazing:**

After freezing, the crates of block fish are immersed in a water and ice tank to create a thin protective layer of ice on the surface of the frozen fish and then they are stored in the negative cold rooms.

- **Defrosting (Thawing):**

By immersing boxes of frozen fish in tanks filled with water under a continuous stream of water for one hour.

- **Filleting, heading, gutting, washing, and draining:**

The fish are headed and gutted manually, removing scales and residual blood, and paying attention to dead larvae.

- **Preparing the marinade:**

It is done in a marinating basin by mixing water, vinegar and salt which are stirred carefully until complete dissolution in order to obtain a homogeneous liquid.

- **pickling:**

By filling the maturing tanks with 60% marinade and 40% fish fillets then storing in the cold maturing room.

- **Draining:**

The marinated fish are transferred to crates spread out on the draining tables.

- **Packaging:**

After draining, the fillets are distributed to the workers in small baskets which are then laid out in trays. These are then weighed and adjusted, if necessary, by adding the necessary ingredients (garlic and parsley). Then juicing with oil (sunflower, oilseed, or olive oil).

- **Sealing:**

Hermetic closure made hot by thermo-sealing or manually.

- **Packaging: Labeling, boxing, and palletization:**

The trays are then labelled, put in taped boxes, and palletized.

- **Shipment:**

The products to be shipped are removed from the cold storage room and loaded by forklift into a refrigerated truck.

1.3 Context of the project:

1.3.1 Problematic

Currently, the situation of UNIMER as Small and medium-sized enterprises (MSEs) which always aims to improve is characterized by the appearance of strong competitive potential. The company in such a context must try to maintain its margins and ensure products of irreproachable quality as well as a short and reliable delivery time. However, critical studies of the current state of UNIMER show that it is obliged to optimize its internal flows, improve its productivity, and rationalize the operation of its equipment.

In this context, the organization is trying to establish a new managerial approach which constantly calls into question all activities at all levels with the ambition of being able to improve in order to satisfy an increasingly demanding clientele, while optimizing the manufacturing process, minimizing resource consumption and non-value-added operations. It is this synergy that will allow UNIMER to strive for “everyday excellence”.

As a result, the company is part of the MII program (Moroccan Initiative for Improvement) launched by the Minister of Industry, Trade and New Technologies (MITNT) and the National Agency for Small and Medium-Sized Enterprises (NASMSE), with a view to establishing a Lean Management transformation that encompasses several continuous improvement projects in order to be able to resist market variability, meet customer needs, and improve the overall performance of the company.

Investigating waste is at the center of the Lean approach: materials, time, ergonomics. The approach consists of Suggesting methods and tools to improve performance, by establishing a dynamic of change involving and engaging the teams to move from "what we know to what must be done". (Wahab et al., 2013)

1.3.2 Project definition.

Aiming to identify the aspects of the need for our project, it is necessary to rely on the "5W1H" method (Figure 4), which is a technique for seeking information on a problem and its causes by asking the following questions: (Jang et al., 2005)

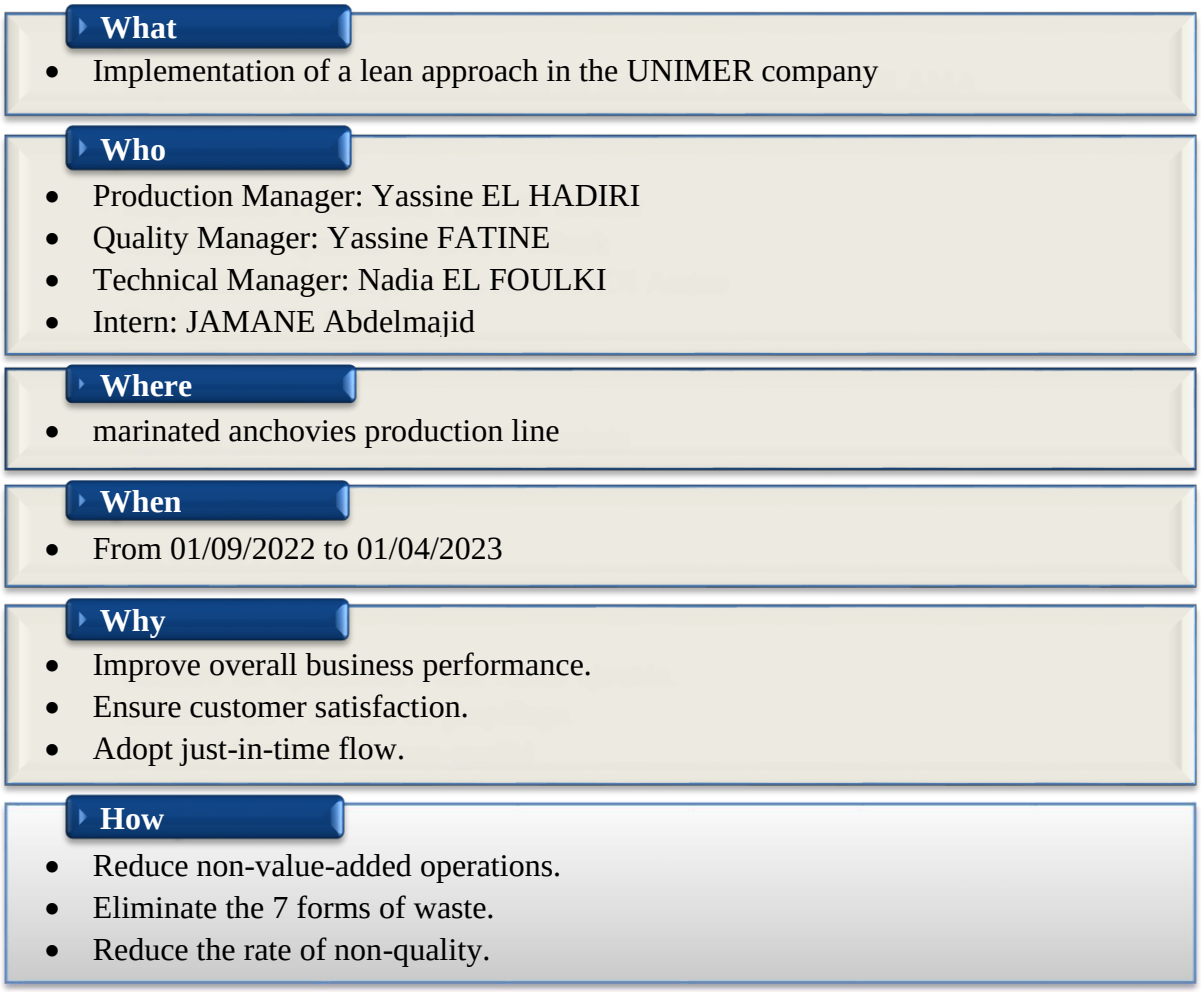


Figure 4: The 5W1H project definition tool: Own construction

1.3.3 The project's objectives.

Aiming to determine the objectives of the project and to describe all the stages which summarize the different missions to be accomplished, we held a meeting with the production manager to agree on the objectives described in the following table:

Table 4: Project's objectives: Own construction

Missions	Goals
✓ Performing active observation.	➢ Determine the value chain and identify waste.
✓ Monitoring of MRTs(Minimum Repeatable Time.	➢ Determine the time required to complete a step in the production process.
✓ Performance monitoring (OEE Productivity).	➢ Study of the current state of performance and its evolution.
✓ Realization of a current VSM.	➢ Modelling the process and identifying non-value added and unnecessary movements in the chain.
✓ Realization of a SMED worksite.	➢ Reduce changeover times on the sealing machine.
✓ Realization of a 5S worksite.	➢ Reorganization of the maintenance area.
✓ Implementation of a problem-solving approach.	➢ Resolution of problems observed by the company (high rate of co-products).

1.3.4 Project approach.

To achieve the objectives determined in the specifications, we have adopted the DMAIC methodology . It is a problem-solving approach that follows a guideline of five steps necessary to obtain reliable results.

Table 5: DMAIC approach of the project: Own construction

Step	Tasks	Tools
1. Define	Project definition. Definition of the project objectives. Definition of the project scope. Definition of the project approach. Project planning.	5 W1H DMAIC GANTT Chart
2. Measure	Collection of data characterizing the project. Measure production performance. Measurement of the MRTs(Minimum Repeatable Time) of the manufacturing steps. Machine OEE measurement. Realization of VSM maps.	Pareto Diagram Timing Follow-up sheets VSM Maps key performance indicators
3. Analyze	Analyze measurement results. Implementation of an improvement action plan.	key performance indicators Brainstorming Ishikawa Diagram Pareto Diagram 5 W1H
4. Improve	Problem solving Worksite. SMED (single-minute exchange of die) worksite. 5S project. Realization of the future VSM.	Pareto Diagram Ishikawa 5S checklist Kaizen
5. Control	Standardization of results.	Visual management
	Track performance indicators.	Dashboard

1.3.5 Project planning

To carry out this project, a plan from 01/09/2022 until 01/05/2023 is presented in the table below:

Table 6: Project planning: Own construction

N°	Activity	Duration (from, to)
01	Diagnostic and data collection: – Identification of the manufacturing process – Measurement of minimum repeatable time and production rate. – Completion of current VSM – OEE Measurement, Takt Time, – Calculation of production yield	From 01/09/2022 To 31/10/2022
02	Data Analysis: – VSM Analysis – Identification of existing types of waste – Analysis of machine stops – Calculation of waste rate	From 01/11/2022 To 30/12/2023
03	Implementation of an action plan: – Setting up a project: • SMED • Problem Solving • Kanban • 5S	From 01/01/2023 To 28/02/2023
04	Action Plan Follow-up: – Realization of the future VSM. – Implementation of two standards: • SMED standards • Manufacturing process standards	From 01/03/2023 To 15/03/2023
05	Writing the thesis report	From 15/03/2023 To 30/04/2023

Description of the expected results of the whole research, description of its possibilities of application/adoptation, its exploitation in short.

Table 7: Project expected results: Own construction

OBJECTIVES	METHODS	EXPECTED RESULTS
C1: Reduce time and non-value added operations	PDCA SMED	By applying those methods we will reduce the time and non-value added operations to 20%
C2: Eliminate the 7 forms of waste	JIT 5S	Reduction of waste to an acceptable level.
C3: Reduce the rate of non-quality	VSM FMECA	Reduction of non-quality and improvement of the quality of the manufacturing process.

At the end of this thesis the expected results in general are, eliminating waste and reducing the time spent on non-value-added activities in order to improve productivity.

2 Literature review

This chapter will be dedicated to the presentation of the Lean Manufacturing tools used, as well as the work approach adopted during the project. We start with the definition of Lean concept its history and we then detail the tools we will use to complete our project.

2.1 Presentation of Lean Manufacturing:

The term Lean is used to qualify a production management theory which focuses on "Management without waste", or "management at the lowest cost.". The main principle of Lean is to maximize customer value by minimizing waste. A Lean organization embraces the value of the customer and focuses its key processes to increase it steadily. The ultimate goal being to provide the ideal value to the customer through a value creation process that has zero waste (2). Lean Manufacturing therefore links performance (productivity and quality) to flexibility of a company, which must be able to constantly reconfigure all its processes (industrial reactivity) in order to provide the customer with what he wants, when he wants, using a minimum of resources (raw materials, equipment, labour, space, etc.) by gradually eliminating the non-added value. (Gupta & Jain, 2013)

2.2.1 The principles of Lean Manufacturing:

The book "the basics of Lean Manufacturing" cited five basic principles for conducting a Lean approach (3): (Bédry, 2009)

- Defining value according to the eye of the customer:

Search and understand what the customer will agree to pay to satisfy his need both objective and subjective according to the time/quality/price triptych. The value: it is the estimate of the service or product provided for the customer as he defines it. We differentiate between two categories of values: (Sundar et al., 2014)

Added value: All activities that increase the value of the product to consumers. eyes of the customer, i.e. the activities for which the customer is willing to pay.

Non-value added: are all things that do not add value to products and services to customers.

The following diagram summarizes the first principle of Lean:

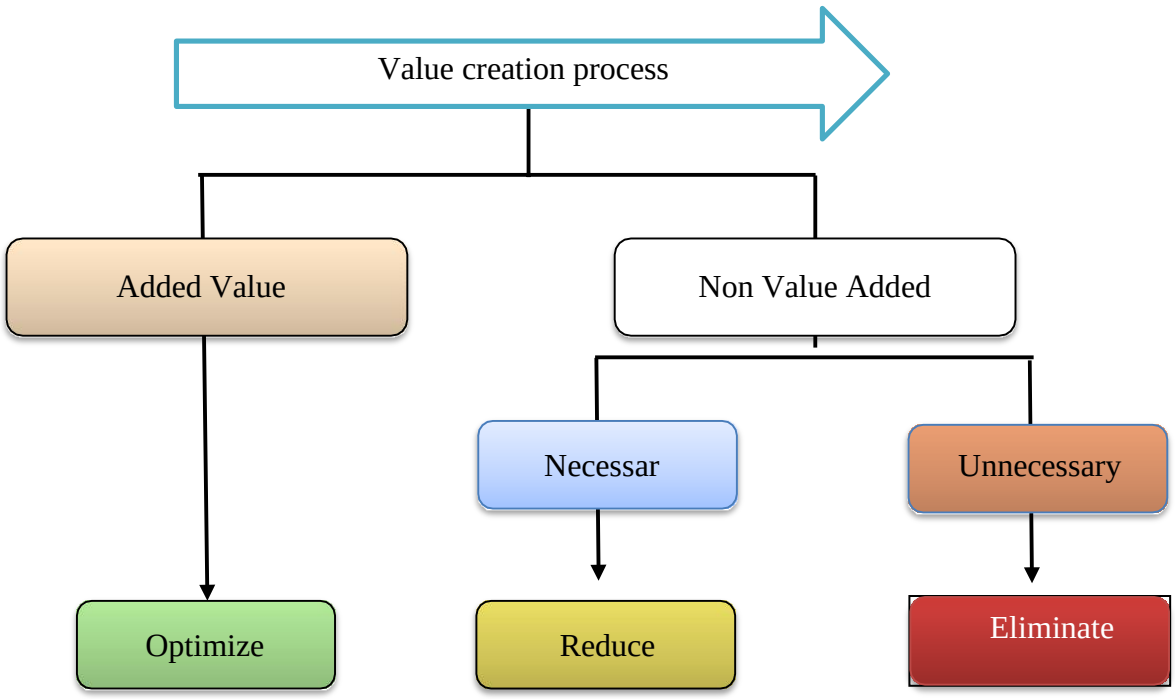


Figure 5: Value creation process: Own construction

- Identify the flow of value creation and eliminate waste:

Waste represents non-value added operations between each stage of the value creation process, but also all the useless actions carried out at the heart of these process. They consume resources without adding any value to the product.

- Establish a customer-driven value stream (VSM)

Identify all value-added operations in order to be able to simplify and improve them. Indeed, flow mapping (VSM) makes it possible to identify all non-value-added operations that represent waste in the Lean approach in order to tend towards their reduction. elimination.

- Pull streams from the client.

Prefer the management of the flow by the real needs of the customer rather than by estimates. Pulling flows means reducing stocks (indirect and direct costs), as well as the risks carried by these stocks (unsold, damage, expiry date).

- Strive for perfection through continuous improvement (Kaizen).

Set ambitious goals and nurture a culture of continuous improvement for reach. It is not only constantly working to improve the process of creating value, but also tighten flows in order to reveal hidden waste, to eliminate it and continue to progress.

2.2.2 Typology of waste:

There are three types of waste:

- Muda: The mess

The Muda are losses of the industrial organization. They are unproductive activities that do not add value to the customer. In practice, it is almost always equivalent to seek to reduce transit time than to seek to reduce losses. For this reason, experts have classified this waste according to 7 types which are as follows (2): (Gupta & Jain, 2013)

- Overproduction:

It is to produce more than the customer needs. We consider all resources that have been allocated to unsold production to be lost. materials, labor, equipment wear, and energy should only be incurred for what the customer is willing to buy.

- Non-quality:

It includes rejects, alterations, as well as all processing activities of complaints. It doubles the cost of the part (the refused part must be replaced)

- Transport:

We consider as a loss all the movements internal to the factory, between the workstations or between different workshops. During a Lean improvement project, the distances will therefore be a specific indicator to be put in place to assess the different solutions.

- Unnecessary movement:

It is an unnecessary move that does not bring value to customers and can be caused by poor organization of the workstation, due to poor ergonomic storage. That may also be due to poorly positioned, listed material or information.

- Waiting time:

They concern products or people who have to wait between two tasks or steps. But also, a machine rate that is too low, so a machine that does not work at its rate optimum or even a series changeover time which is much too long.

- Over-stocking:

Inventories appear in the list of losses, not to mean that all work in progress and inventory of finished products must tend towards zero, but for them to be controlled regardless of or type of industry.

- Unsuitable processes and methods

These are tasks, steps carried out for nothing in a process that is too complex compared to at the selling price too many qualities, too many materials, too much information or even a lack of instructions or clear and standardized specifications.

- Muri & Mura: excess and irregularity:

Muri: Means that which is excessive, unreasonable, excessive effort, overwork.

Mura: Means variation. These are the jerks of production and all the irregularities of flows that require the establishment of buffer stocks and work-in-progress.

2.2 key performance indicators

2.2.1 MRT (Minimum Repeatable Time):

- Definition:

The MRT: it is the cycle time measured on observed production cycles. It is repeated at least three times.

- The Purpose of calculating the MRT:
  - Minimum: because the company aims for excellence.
  - Repeatable: there is no doubt about its reachability.
  - The objective is not to align everyone on the minimum, but to identify. the causes of variability.

2.2.2 OEE (Overall equipment effectiveness)

- Definition:

It is a business performance indicator, which measures industrial performance. It makes it possible to answer many strategic questions (actions to be taken to optimize production, organizational efficiency, need for investment) (4). It consists of three components:

- The availability of the machine or equipment.
- The performance of the latter, in normal conditions.
- The quality it is able to provide.

The OEE condenses these elements into a single figure expressed as a percentage to facilitate management and help decision-making. It is a key indicator for production management (4).

2.2.2.1 OEE calculation equation

$$\mathbf{OEE} = \text{Availability rate} * \text{Performance rate} * \text{Quality rate}$$

2.2.3 Takt Time:

- Definition:

TAKT is a German word borrowed from musical language and designating rhythm or rate. Takt is the rhythm on which you have to set yourself up to get in step with the demand.

2.2.3.1 TAKT TIME calculation equation

$$\mathbf{TAKT\ TIME} = \text{available time} / \text{Customer Order}$$

The purpose of the Takt Time indicator is to:

- Adapt to fluctuations in customer demand, without losing efficiency.
- Reduce the number of operators to do the same task.
- Reduce their stress and the hardship of the work.

2.3 Lean Toolbox:

To improve the productivity of the company we have used a toolbox of Lean in order to solve specific productivity problems. There are nearly a hundred tools and methods to improve operations and productivity.

2.3.1 VSM, flow mapping:

- Definition:

VSM (Value Stream Mapping) Mapping was popularized by Mike Rother in through his didactic book "Learning to see". It is a relatively recent Lean tool, derived from Toyota's MIFA (Material and Information Flow Analysis) (5). (Bédry, 2009) (Faulkner & Badurdeen, 2014)

VSM consists of tracing the physical flow of materials, parts, or products along the process, as it is, with all the twists and turns and deviations as they appear in reality. The corresponding flow of information will be traced on the same map, which can materialize by:

- IT orders;
- Placing of orders;
- Mails exchanges ;
- Telephone exchange.

The family of products on which this study will focus on before starting the fairest approach is determined. The drawing of a map of the value chain is done by walking in factory and by drawing, step by step, the various similar processing steps, on the same. equipment (same manufacturing range). (Fontanille et al., 2010)

- VSM design steps:

The practice of this analysis is done in four distinct stages: (Ballé, s.d.)

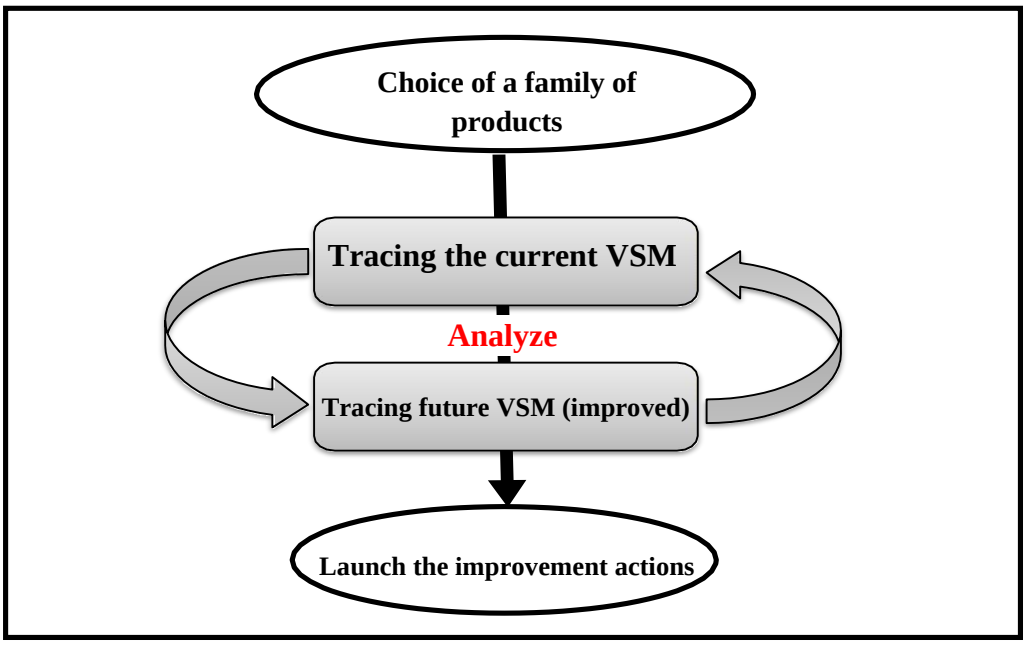
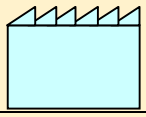
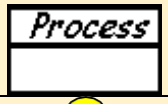
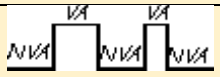
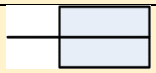
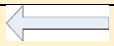


Figure 6/ VSM design approach

The VSM diagram is made using a template of specific symbols called pictograms. The most used are grouped in the following table: (Hohmann, 2011)

Table 8: VSM symbols

Pictogram		Description
	Customers and Suppliers	Represents the supplier when it appears in the upper left corner. The customer is at the top right, the usual end point to deliver the product.
	Process or activities	Represents a service, an operation in the process or a machine managing a fixed and continuous flow of materials.
	Operator (Worker)	This icon is used to show how many operators are needed to manage a workstation.
	lead time	The time required to perform an activity or process.
	Shipping by truck	The truck icon represents outbound shipment to customers or from vendors.
	Inventory	Stock between two processes.
	Go to check	Observation to gather information.
	Digital information	Electronic data interchange. (EDI)
	Manual information	Manual information from memos reports or conversations.
	Chronology	It is placed at the bottom and indicates waiting times and processing times. It is used to calculate the total cycle time.
	Forcing arrow	It designates products that are pushed downstream, from one process to the next.
	Data box	It is necessary to analyze the data of each process.
	Products transported to the customer	Represents the movement of raw materials from suppliers to the factory receiving dock. Or, the movement of finished products from the factory to the customer.

2.3.2 Problem solving method:

- Definition:

To solve a simple problem, it is necessary to have common sense, to adopt a rigorous approach and to use adapted tools. To meet these different needs. There almost all problem-solving methods revolve around a variable number of phases among which there are four essentials according to the Deming wheel, and which are: Plan, Do, Check, Act (PDCA). (Realyvásquez-Vargas et al., 2018)

- Problem solving approach according to the Deming Wheel: (alfraconsulting, s.d.)

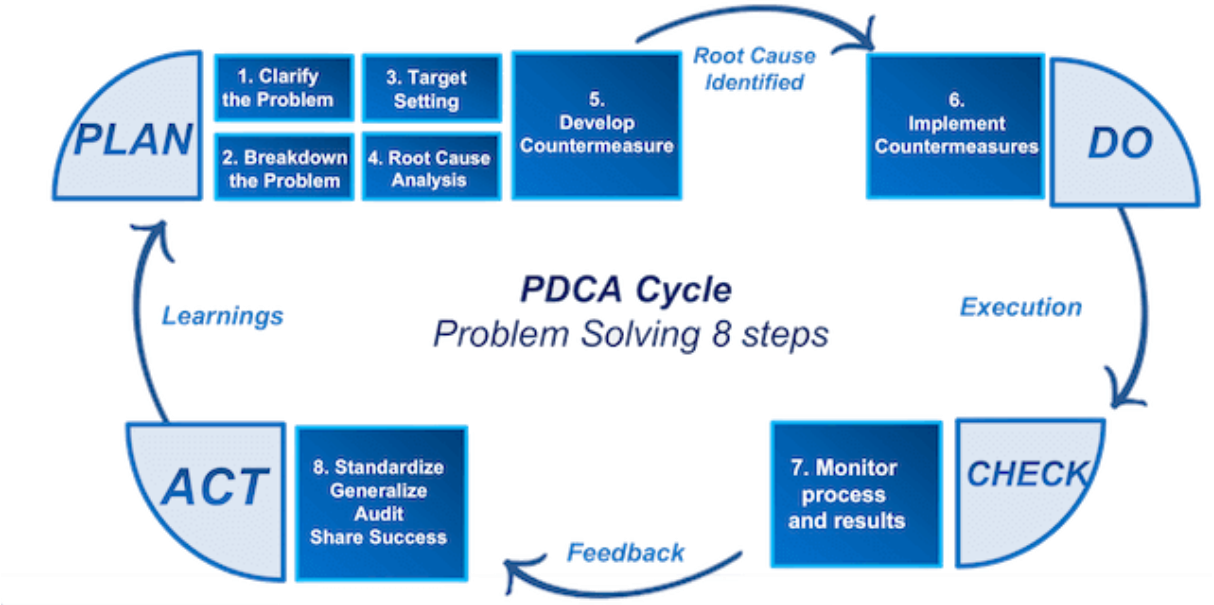


Figure 7: Problem-solving approach based on the PDCA wheel principle.

2.3.3 Kanban:

- Definition:

KANBAN It is a Japanese word that reflects a label or card bearing information relating to the packaging (product) with which it is associated. It is used to signal to the station which is upstream what needs to be produced at the post that is downstream. (2) (Ramnath et al., 2010)

2.3.3.1 Calculation of the number of Kanbans.

$$N_k = \text{Threshold} + (Ac * D + Ss)/N$$

Threshold: number of containers corresponding to supply contingencies (of the supplier).

Ac: Customer's average consumption per unit of time.

D: Time to replenish a container of parts.

Ss: Safety stock in parts, for uncertainty on D.

N: Capacity of the container in number of pieces.

2.3.4 5S method:

- Definition:

The "5S" occupy a place of choice among manufacturers. It is one of the best practices recognized and implemented by manufacturers (6).

- Meaning of 5S:

The “5S” refers to a process whose acronym recalls the five action verbs:

- Seiri : Sort
- Seiton : Straighten
- Seiso : Shine
- Seikutsu : Standardize
- Shitsuke : Sustain

Those words are from Japan, the "5S" is an approach that begins with the development of the physical space, and which will quickly lead to the management of the place concerned. The “5S” are based on the observation that a clean and tidy space is conducive to the production of good quality (6).

2.3.5 SMED method (Single Minute Exchange of Die)

- Definition:

The SMED or Tool Exchange in less than 10 minutes, is an organizational process which seeks to systematically reduce the changeover time of series, with an objective quantitative (7). Among the things that most penalize the productive performance of machines is the duration and frequency of series changes. (Mali & Inamdar, 2012)

- Basics of SMED

The SMED approach is used to minimize internal operations and maximize operations external. The transition from an internal operation to an external operation is called "conversion".

- Internal operations: are operations which can only be carried out if the machine is stopped.
- External operations: are operations that can be performed while the machine is running, without stopping it.

- Steps in setting up the SMED:

The SMED methodology goes through 6 fundamental steps:

- Measure the total duration of the change.
- Identify external and internal elements.
- Transform internal elements into external elements.
- Reduce internal elements.
- Reduce external elements.
- Standardize and perpetuate the new change procedure (8).

3 Research methodology

Aiming to have a global vision on the current performance of the semi-preserved production line within the UNIMER company. This chapter is devoted to a depth study of the existing situation based on diagnostic tools, with a view to proposing action plans that will ensure a significant reduction in non-value-added operations and all kinds of waste.

3.1 Diagnosis of the existing

3.1.1 Construction of the VSM map of the current state

This is one of the best practices for starting a flow improvement project. It is used in the diagnostic phase to visualize the entire production chain, from raw material to finished product. Before developing the VSM map, the calculation of its key indicators will be carried out.

- Used Indicators

To facilitate the interpretation, understanding and analysis of the maps, we have set up a set of indicators:

- Lead time: Is the total time it takes for a batch to go through the entire manufacturing process.
- Cycle time: This is the time elapsed between the manufacture of one batch and the manufacture of the next batch, measured at the same point in the process.

To do this, we have chosen the following approach: (Ballé, s.d.)

Figure 8: VSM mapping construction process: Own construction

- Collection of information to carry out the VSM mapping.
- Product choice:

To limit the number of references we will take in consideration in the rest of the study. We have taken an example of the orders (Appendix I) of the two customers of the company (CAROLINO and SEA DELIGHT). We started with a classification according to the quantity ordered by customers. According to the results of the study carried out (Figure 8), the Belmonte Gourmet reference (Figure 9) is the most requested, which will facilitate the detection of bottlenecks. (Deshkar et al., 2018)

The following (Figure 9) represent the classification of articles according to the ordered quantity (see Appendix I)

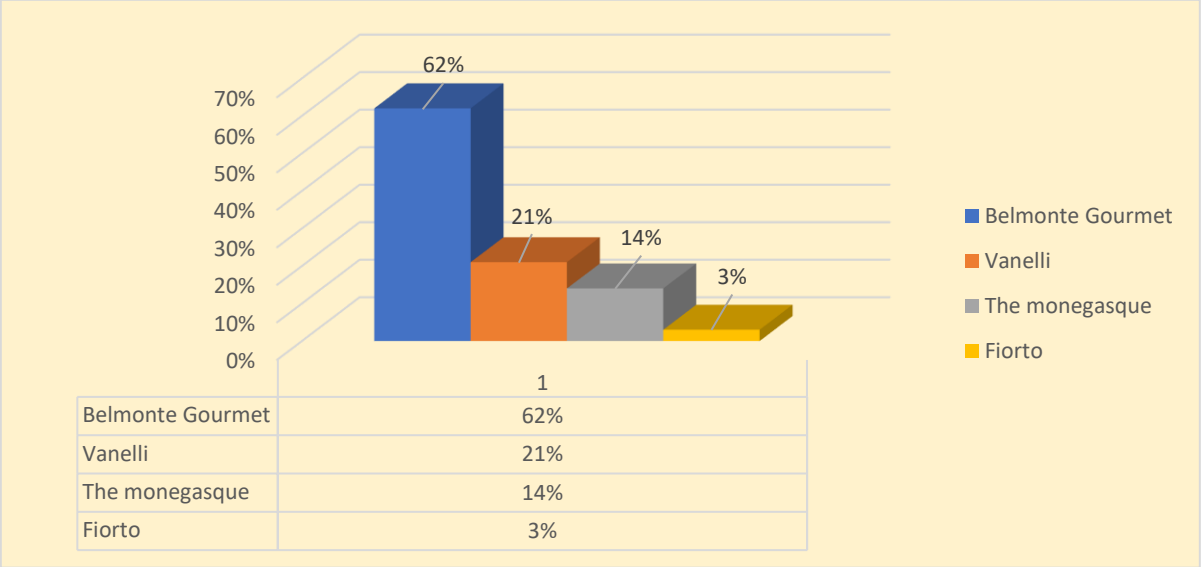


Figure 9: Classification of articles according to the ordered quantity (UNIMER, 2023): Own construction

Figure 10: Belmonte Gourmet (UNIMER, 2023)

- Observation of operations and calculation of MRTs (Minimum Repeatable Time)

In this stage we observed the anchovy processing operations in the different areas, then a calculation of the MRTs (Minimum Repetitive Time) was carried out.

10 threading operation samples from 10 women are taken to obtain reliable results.

Table 9: MRT Thread area: Own construction

Date of analysis	MRT: Thread area										Average MRT
Sample N°	1	2	3	4	5	6	7	8	9	10	
MRT (s)	2,34	3,17	4	2,71	3	3,8	2,52	3,14	3,2	4,02	3,2 s
MRT (s)	3,44	2	3,58	2,68	3,22	2,37	3,57	3,01	3	3,2	3,0 s
MRT (s)	3.02	3.20	3.14	2.75	2.6	3.8	3.55	4.02	2.3	2.52	3,09 s
Average											**3,09 s**

Table 10: MRT conditioning area: Own construction

Date of analysis	MRT: Conditioning area										Average MRT
Sample N°	1	2	3	4	5	6	7	8	9	10	
MRT (s)	1,42	2,06	1,33	1,11	1,22	1,35	1,56	1,56	1,11	1,12	1,4 min
MRT (s)	1.37	1.59	1.22	1.56	2.03	2.01	1.36	1.55	1.49	1.03	1,52 min
MRT (s)	2.00	1.33	1.18	1.25	1.34	1.5	1.36	1.22	1.35	1.09	1,36 min
Average											**1,42 s**

From the tables above, the average MRT is taken as the cycle time for filleting and packaging operations.

- . Work rate

To better understand the situation of the company we are going to approach a study on the cadence (rate) of the posts which makes it possible to determine the speed of production (rate of production), which represents the ratio between the number of elements produced in a production time, for a given workforce. The calculation results are presented in the following table:

Table 11: work rate: Own construction

Poste	Rate	Quantity to produce /day	Cycle time
Thread	▪ 2 boxes of anchovies / hour / operator ▪ Box weight: 10kg ▪ 32 operators	32×2×10×8= **5120 kg**	3.09 s
Pickling	▪ Maturation tray: 42 buckets ▪ Each bucket contains 5kg	42×5×20 = **4200 kg**	2 min
Conditioning	▪ 30 trays (BELMONTE) / hour / operator ▪ Number of workers: 50 ▪ Opening time: 8h	30×50×8 = **12000 units**	1.42 min
Sealing	▪ rate of the Machine (BELMONTE): 810 b/h	810×8 = **6480 units**	36 s
Packaging	▪ 95 trays / box ▪ 72 boxes/pallet	95×72×2= **13680 units**	46 s
Expedition	▪ 33 pallet/truck	□	

- Drawing of the current state:

The flow chart for fresh anchovies is presented in the following figure:

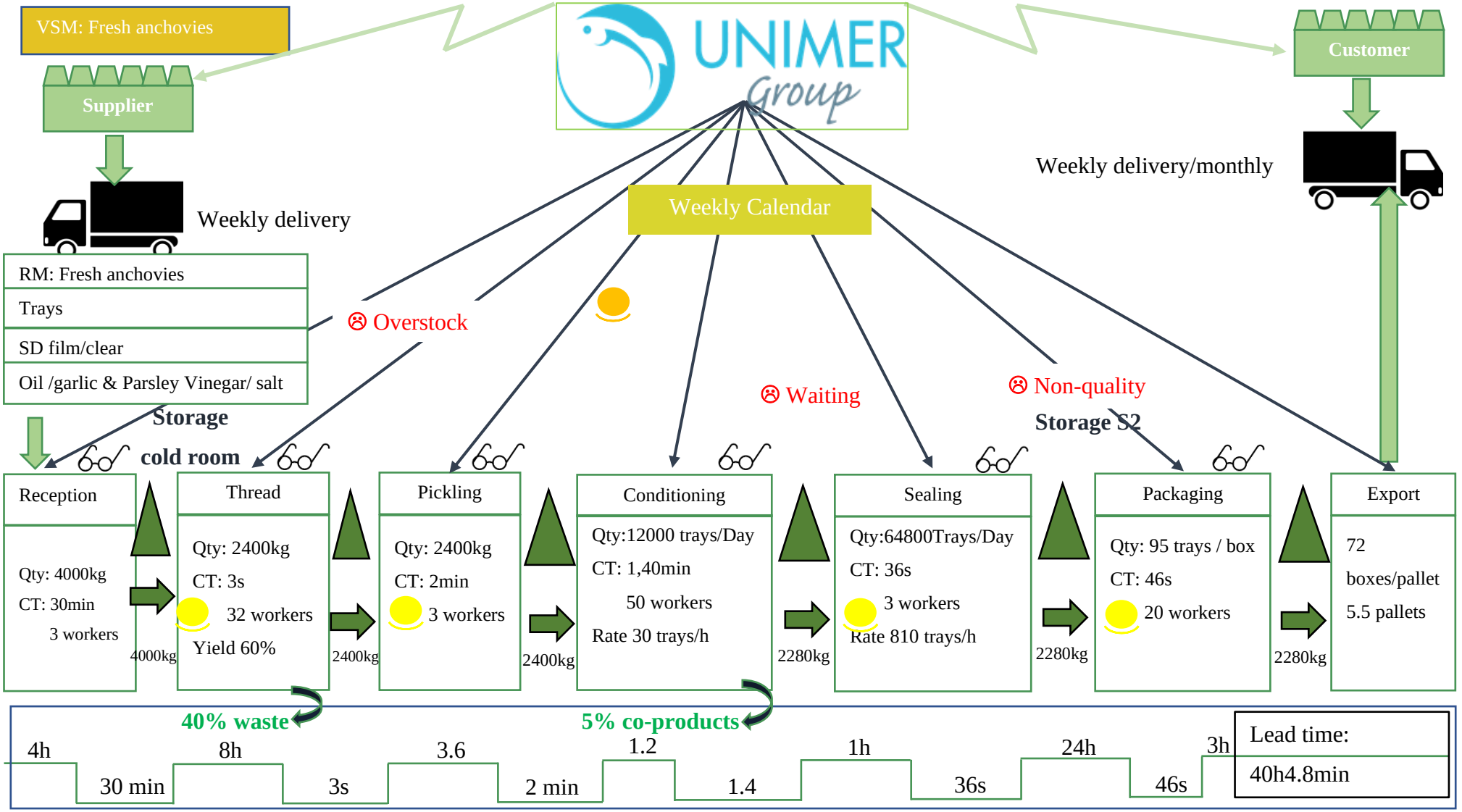


Figure 11: VSM chart of Fresh anchovies: ***Own construction***

- Analyzes of the current VSM of fresh anchovies

The quantity of fresh fish is 4 tons. This quantity can be threaded in a day, with a fixed waste rate of 40%. Which will give 2.4 T as the quantity ready to be marinated. During packaging stage, each one of the 50 operators can process 30 trays/h which is 12,000 trays / 8 hours, while in the sealing stage the machine can seal only 6480 trays / 8 hours working non-stop in an ideal case. Thus, with the 4Tons we obtain 38000 trays (BELMONTE). According to the analysis of the VSM, it appears clear that the manufacturing process is conditioned by two bottlenecks:

- Waiting time

Which is due to the low sealing machine rate which fixes the maximum quantity that the machine can seal per day which leads to a certain quantity of the product being grouped before the sealing (bottlenecks) which clutters the production area.

Figure 12: Waiting before sealing: (picture taken during the production)

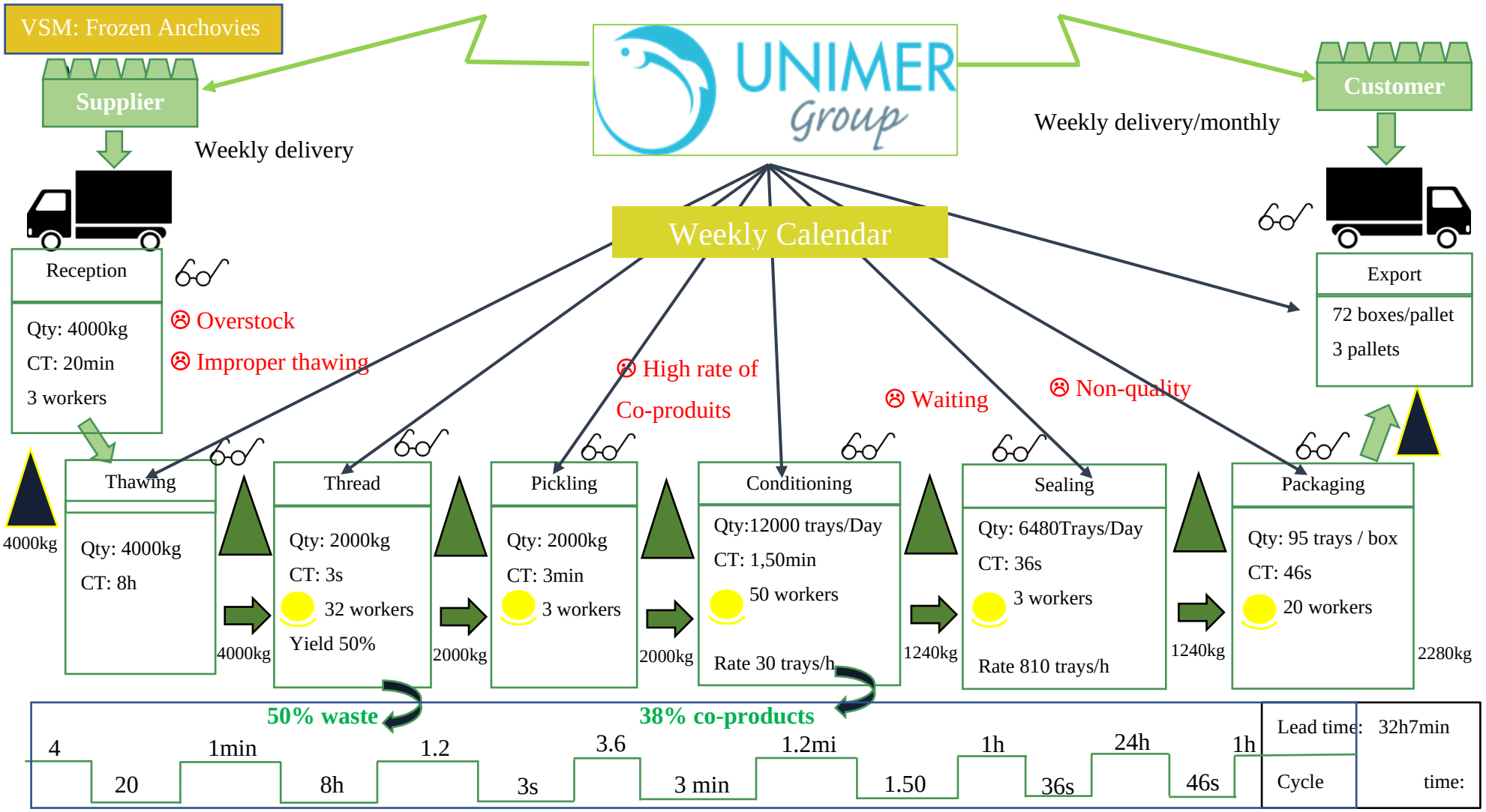
- Non-quality

Which is due to defective products caused by the sealing machines due to technical problems.

Figure 13: Non-quality Products

- Case of frozen anchovies:

Now we will draw the flow map for frozen anchovies. We are going to take the same quantity of anchovies to compare their performance.



Caption:	Quantity processed: 10000 Trays
Product: Marinated anchovy fillets	Drained Weight: 60g
Packaging reference: BELMONTE	Number of trays produced by the quantity of anchovies: 1240000g/60g= 20666 trays=217 boxes=3 pallets

Figure 14: VSM chart of Frozen Anchovies: ***Own construction***

- Analysis of the current VSM of frozen anchovies:

According to the cartography above, the waste rate takes half of the anchovies (50%). This represents for the two conforming tons a quantity of 26666 trays (BELMONTE). It also appears clear that the defrosting process takes too long that described in the manufacturing process. This generates a high non-quality rate.

3.1.2 Production yield study:

To monitor the state of production, a yield study was carried out. The performance of frozen or fresh anchovies is expressed by a percentage obtained by comparing the gross weight of the product and the usable quantity at the end of the various processing phases. Analysis of fish reception history and production data allowed us to calculate fish material yield. This following table presents the yield of anchovies as well as the waste rate during the month of March: (Neumann et al., 2010)

Table 12: Thread yield for the month of March (own construction)

Thread yield for the month of March					
Date	Quantity received (kg)	Quantity of fillets (kg)	% fillets	Quantity of waste	% waste
15/09/2022	2840	1530	54	1310	46
16/09/2022	3000	1625	54	1375	46
17/09/2022	338	310	92	28	**8**
20/09/2022	2455,6	1115	45	1340,6	55
22/09/2022	744	270	36	474	64
24/09/2022	1014	420	41	594	59
26/09/2022	2446,5	990	40	1456,5	60
27/09/2022	750	270	36	480	**64**
29/09/2022	3042	1130	37	1912	63
30/09/2022	4000	2000	50	2000	50
03/10/2022	2346	1150	49	1196	51
04/10/2022	4622,4	1855	40	2767,4	60
05/10/2022	2967	1270	43	1697	57

The following (Figure 15) represent the Thread yield for the month of March obtained from the data of the (table 12)

Figure 15: Thread yield for the month of March

- Analyzes and results:

According to the previous results we notice that the high percentage 64% of waste comes from frozen anchovies and it is the same for the other rates except one which is very low which is from fresh anchovies. This study shows that fresh fish is more profitable than frozen anchovies, and that triggers the freezing and thawing operation.

3.1.3 Analysis of indicators:

- Takt-Time:

The calculation of the Takt Time makes it possible to know the rhythm on which the company must stall to respond to the command in time by comparing it with the cycle times of each process. We take as an example an order (Appendix I). (Frandson & Tommelein, 2014)

Table 13: Takt time calculation (own construction)

Monthly available time in (s)	576000 s
Customer request/month	110000 Trays
Takt Time (s/T)	5.23 s/T

The following (Figure 16) represent the Graphical comparison between Takt Time and cycle time obtained using the data from (table 11) and (table 13)

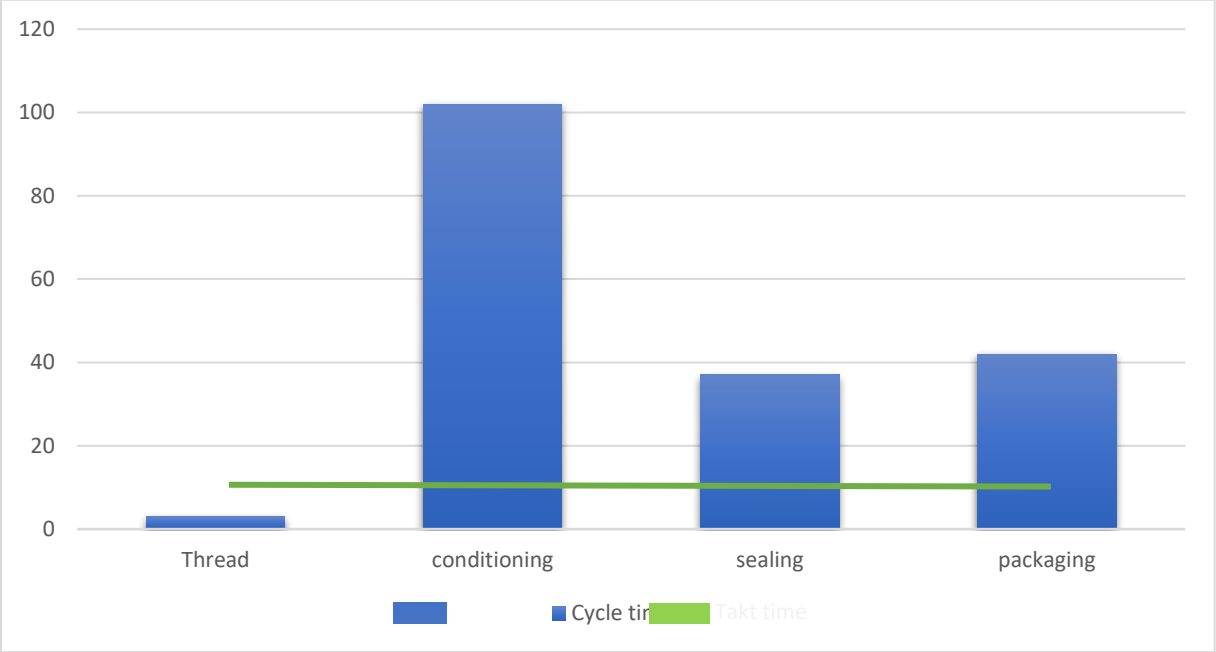


Figure 16: Graphical comparison between Takt Time and cycle time

Looking at this graph, we see that the conditioning step, sealing, and packaging represent the bottlenecks because their cycle times exceed the Takt Time.

- OEE:

The monitoring of the **OEE (Overall equipment effectiveness)** is done daily. In fact, the operator who is responsible for sealing completes a stop form in which he indicates the type of stop, the duration of the stop, and the description of the stop. At the end of each day, these sheets are collected and entered by the production manager on Excel spreadsheets, in order to calculate the various indicators of production. An example of a OEE tracking sheet is attached in Annex II. (Sohal et al., 2010)

We did a daily monitoring of the OEE of the sealing machine during the 8 weeks months of February and March. The results of the calculations are presented in the following table:

Table 14: monitoring of the OEE. (own construction)

Week	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**
OEE	64	61	61	63	65	63	70	75
Objectifs (%)	80	80	80	80	80	80	80	80

The following (Figure 17)represent the graphical results of OEE monitoring obtained using the data of the (table 14)

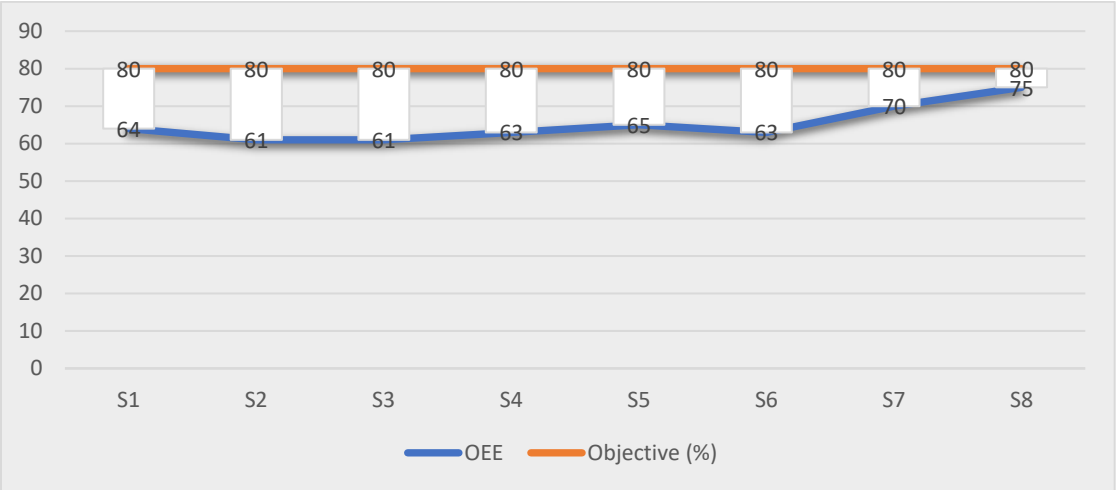


Figure 17: Graphical results of OEE monitoring.

- **Analyzes and results:**

According to these results we find that the OEE is variable without the achievement of the objective set. by the company which is 80%. This requires a detailed analysis of the losses caused by downtime to focus on the most penalizing.

To do so, we have accumulated throughout this period, the durations of stops occurring on the line in minutes. The objective is to highlight the significant losses compared to the less significant ones as reflected in the following table and Pareto diagram:

Table 15: Sealing machine downtime tracking report. (own construction)

Date	N° Of stop	Type of stop	Stop duration in (Minutes)
15/10/2022	6	Film MB problem	60
16/10/2022	5	Oil weight	10
17/10/2022	10	Machine technical problem	180
21/10/2022	9	Waiting for Parsley	10
22/10/2022	4	Mold change	35
	13	Lack of oil	95
23/10/2022	4	Mold change	35
	9	Waiting for Parsley	15
24/10/2022	7	Product change	36
25/10/2022	10	Machine technical problem	40
28/10/2022	10	Machine technical problem	210
29/10/2022	4	Mold change	30
	13	Lack of oil	60
30/10/2022	10	BELMONTE machine problem	240

01/11/2022	10	BELMONTE machine problem	95
02/11/2022	10	Compressor problem	240
05/11/2022	8	Waiting for Production	20
06/11/2022	4	Mold change	35
	2	film adjustment	100
07/11/2022	8	Waiting for Production	110
08/11/2022	8	Waiting for VANELLI production	180
10/11/202	4	Mold change	45
11/11/2022	13	Waiting for Oil	70
12/11/2022	13	Waiting for Oil	64
13/11/2022	13	Waiting for Oil	80
14/11/2022	7	Product change	25
15/11/2022	4	Mold change	38
	7	Product change	142
16/11/2022	4	Mold change	40
	11	product problem	153
18/11/2022	6	Film problem	15
	9	Waiting for Oil	16
19/11/2022	4	Mold change	90
20/11/2022	1	Film change	11
	8	Waiting for Production	12
21/11/2022	9	Waiting for Parsley	37
	8	Waiting for Production	43
22/11/2022	1	Film change	39
	8	Waiting for Production	180
23/11/2022	7	Product change	10
	1	Changement de film	5
24/11/2022	2	film adjustment	43
	10	Machine technical problem	3
25/11/2022	6	Film problem	14
	10	Machine technical problem	9
	13	Waiting for Oil	24
	7	Production change	14

In the following table we have gathered the durations of each stop according to the 13 stops identified at the production leve

Table 16: The cumulative time of the 13 types of sealing machine stops. (own construction)

N° of stop	Type of stop	Stop duration in (Minutes)
1	Film change	55
2	film adjustment	143
3	Oil change	0
4	Mold change	348
5	Oil weight	10
6	Film problem	89
7	Product change	227
8	Waiting for production	545
9	Waiting for Parsley	78
10	Machine technical problem	1017
11	Product Problem	153
12	Machine cleaning	0
13	Lack of oil in the tank	546

From the data in the table above we draw the following Pareto chart:

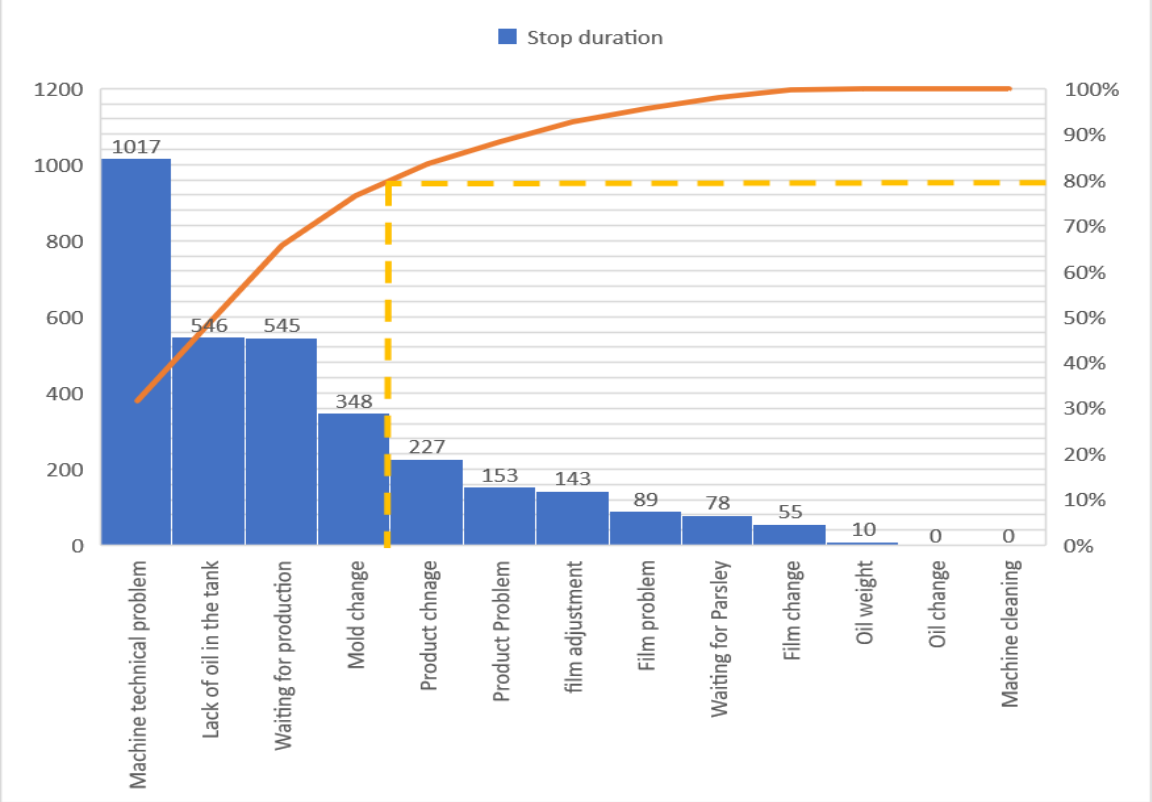


Figure 18: Pareto chart for sealing machine downtimes.

This diagram shows that the first 4 stops are responsible for 80% of the lost time, whence the need to retain them. What remains for us is to implement preventive actions and solutions to reduce these downtimes (Stops) which affect the OEE (**Overall Equipment Effectiveness)** of the machine.

- **Scrap rate (co-products):**

The scrap rate is an indicator that allows us to focus on the number of products that are thrown in the trash because they have no market value. UNILMER scrap are poorly sealed trays and co-products resulting from the packaging process.

During our internship we found that the rate of co-products from production exceeds the threshold set (20%) with a very significant margin, particularly in 2022 the average rate is 38% result from frozen anchovies unlike fresh anchovies which give a rate low level of co-products (between 9 and 10%) which means that production is faced with a large problem that needs to be resolved quickly.

A comparison of the rates of co-products from fresh anchovies and frozen anchovies was carried out to see the difference and focus on the component that generates a high rate of co-products. The following table shows the regular, daily monitoring of rates carried out by the production manager from the start of 2023.

Table 17: Rate of pieces from frozen anchovies (own construction)

Months /2022	% coproducts	Production yield
October	32%	62%
November	53%	
December	29%	

Table 18: Rate of pieces from fresh anchovies (own construction)

Date	% coproducts	Production yield
15/12/22	3%	95%
17/12/22	4%	

3.2 Implementation of the action plan to improve the current state:

The diagnosis that we carried out on all the net production processes of marinated anchovies, thus the key production Minimum Repeatable Time allowed us to identify the sources of losses in the current operational system, and to identify gaps and weaknesses in the managerial infrastructure. According to the problems defined, and their main causes an effective action plan was put into action is articulated in:

- Application of SMED method.
- Resolution of the problem of the high rate of co-products according to the principle of PDCA.
- Establishment of standards
- Implementation of 5S
- Implementation of a Kanban system

3.3 Discussion and results: Deployment of lean manufacturing tools

After diagnosing the product production line, identifying the bottlenecks that need to be improved, and know the applicable tools and methods. This chapter will be dedicated to the implementation of all Lean methods and tools, in order to increase the profitability of production processes, and solve as much as possible, the problems that generate the bottlenecks of pre identified strangulation.

3.3.1 SMED worksite:

The diagnosis of the existing showed that the series changes made on the machine seals represent critical time-wasting issues, thus influencing overall production performance. To improve this state, a SMED project will be set up, aimed at reducing these production changeover times.

- Targeting workstations:

Since the company only has one machine and on which the majority of the work is done, is it necessary to follow this machine, and reduce its changeover time? series. This first step consists in describing in a general way the progress of series changes on the heat-sealing machine. In this context, we focused the analysis changes taking place in the different stages of sealing.

- Observation by video recording:

To carry out this method, we observed the entire tooling change through a video that was made on 02/20/2023. To properly prepare this recording, we have a meeting was organized with all the actors of the project including the production manager, quality manager and the technical manager. The purpose of the operation and take into account the different activities of the change of series to describe all the aspects of this stain. These videos allow you to capture all the information, then analyze it with our working group. It is therefore possible to carry out with precision the breakdown into elementary operations and to examine all the problems, returning, if necessary, to certain sequences.

- Determination of tool change operations:

From the information collected from the video, we have listed the different elementary operations constituting the change of tools. This decomposition is carried out as a group, in collaboration with the maintenance manager, the production manager and the Quality Manager. This observation sheet summarizes all the basic operations observed, as well as the times spent:

Table 19: Calculation of times for series changeover operations; (own construction)

N°	Operations	Duration	Cumulative time (s)
1	Prepare the material (mold/storage/preparation of boxes to put the material)	35	35
2	Stop the machine	2	37
3	Change the position of the rails according to the article	126	163
4	Media storage	10	173
5	Remove the brackets	95	268
6	Rail adjustment	205	473
7	Storage and movement	19	492
8	Dismantle the lower mold	481	973
9	Film setting	52	1025
10	Moving	43	1068
11	Assemble the Bottom Mold	269	1337
12	Dismantle the upper mold	60	1397
13	Joint adjustment	25	1422
14	Moving	17	1439
15	Assemble the upper mold	117	1556
16	moving	81	1637
17	Setting	17	1654
18	Closure of the mold	116	1770
19	Turn on the resistors	2	1772
20	Wait for machine temperature to rise 200°C	568	2340
	TOTAL	**2340**	**2340**

The change of series takes 2340 s equivalent to 39 min for the BELMONTE reference trays. This wasted time is wasted money.

- Classification of operations (Internal and External):

This step completes the observation phase, before moving on to issuing the technical solutions.

We classify operations according to their nature:

- If the operation is carried out while the machine is running (at rated speed and under normal conditions of safety and quality), it is an external operation.
- If the operation requires stopping the machine, it is classified as internal operations.

As a result, the following table classifies transactions according to their nature:

Table 20: Classification of operations: (own construction)

N°	Operations	External	Internal
1	Prepare the material (mold/storage/preparation of boxes to put the material)		
2	Stop the machine		
3	Change the position of the rails according to the article		
4	Media storage		

5	Remove the brackets		
6	Rail adjustment		
7	Storage and movement		
8	Dismantle the lower mold		
9	Film setting		
10	Moving		
11	Assemble the Bottom Mold		
12	Dismantle the upper mold		
13	Joint adjustment		
14	Moving		
15	Assemble the upper mold		
16	moving		
17	Setting		
18	Closure of the mold		
19	Turn on the resistors		
20	Wait for machine temperature to rise 200°C		

The (Figure 19) Below is a distribution of series changeover times in order to visualize the extent of the internal time in the change procedure. It takes almost all of the latter's time. This graph obtained using the data of the (Table 20).

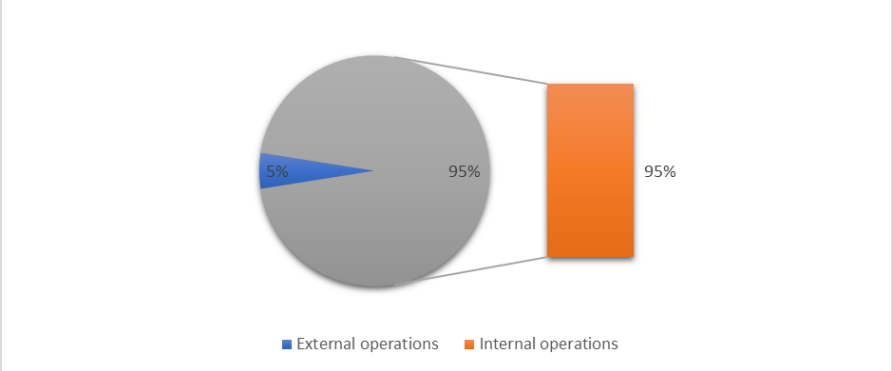


Figure 19: Distribution of changeover time

- Convert internal operations to external operations:

In this step, it is necessary to act on internal operations to transform them into operations external when all external operations are performed in masked time. It is becoming essential, in order to continue to progress, to convert certain internal operations into external. The objective is to reduce as far as possible the number of internal operations, which entail stopping production.

We have tried to outsource internal operations as much as possible. look for operations that can be done while the sealing machine is running and eliminate non-value-added operations and reduce those that can be reduced, and this is the summary of the outsourcing we proposed:

Table 21: Conversion of internal operations into external operations (own construction)

Non-value added operations	Action to take	Duration (s)	Status
Prepare the material (mold/storage/preparation of boxes to put the material)	Purchase of a mobile trolley for the provision of equipment without wasting time	20	Ex
Change the position of the rails according to the article	Reduce changeover time the position of the rails	100	In
Media storage		10	In
Remove the brackets	Buying an automatic screwdriver	80	In
Rail adjustment	To reduce	180	ex
Storage and movement	To eliminate	0	In
Dismantle the lower mold		400	in
Film setting		30	In
Assemble the lower mold		250	In
Dismantle the upper mold		40	In
Joint adjustment		25	Ex
Assemble the upper mold		100	In
Setting		25	In
Closure of the mold		70	Ex
Turn on the resistors		1	Ex
Wait for machine temperature to rise 200°C		560	Ex

Table 22: non-value added operations. (own construction)

Non-value added operations	Duration (s)
Storage and preparation of equipment	35
Moving	103
Screw and unscrew	448
Total	586 s = 9 min 77 s

As we can see some operations of the current series change takes place during the shutdown of production. However, they can be carried out during the operation, for example:

The operator wastes a lot of time looking for the tools, keys, and equipment he will need. Therefore, before any change in series, he must prepare the tools (spanners, chisels, hammer, etc.) to be used, hence the usefulness of the tool panel introduced, which allows easy detection of equipment at hand. using a mobile cart to facilitate the task.

The (Figure 20) Below is the distribution of changeover time after the outsourcing of operations this graph obtained using the data of the (Table 21).

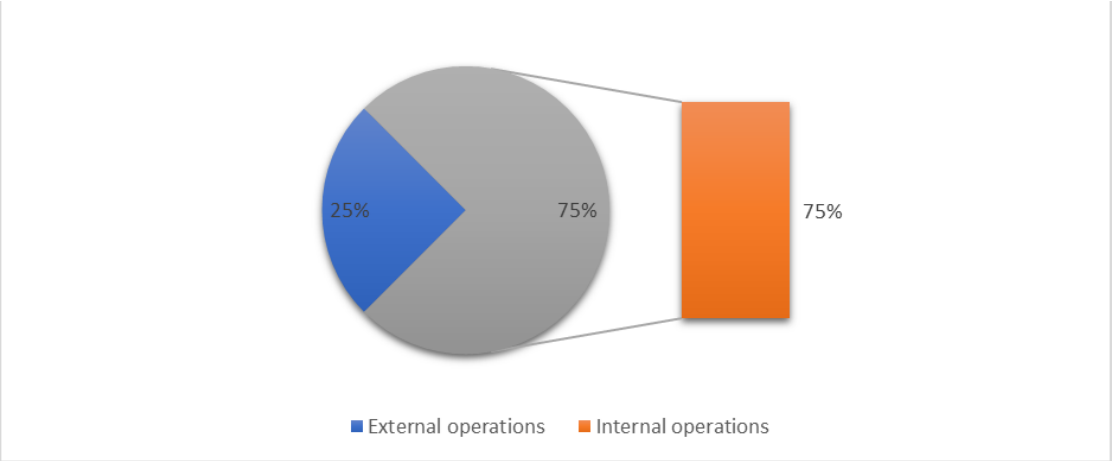


Figure 20: Distribution of changeover time series after SMED

After outsourcing certain operations and eliminating other operations, the company was able to reduce the changeover time to 25 min.

- Standardization:

Through the entire timeline done during the series change. Time to series change represents a significant part of all machine downtime, and often varied from one operator to another, which proves the need to standardize the operating mode in order to unify the mold format change process and increase the rate of production. So, to rationalize this time we have developed a standard for the operation change of mold (Appendix III).

3.3.2 Problem solving worksite.

- Introduction

In our diagnosis we found an indicator which is high in co-products which exceeds the fixed threshold which requires a Lean method to solve this problem. It is for this reason that we are interested in the method of problem solving, according to the principle of continuous improvement PDCA which is based on the steps described above. Thus, a study on the yield of the two types of anchovies: fresh and frozen was carried out. (Novick & Bassok, 2005)

The following (Figure 21) represent the Comparison of yield of fresh and frozen anchovies it is done using the data of the (table 17) and (table 18).

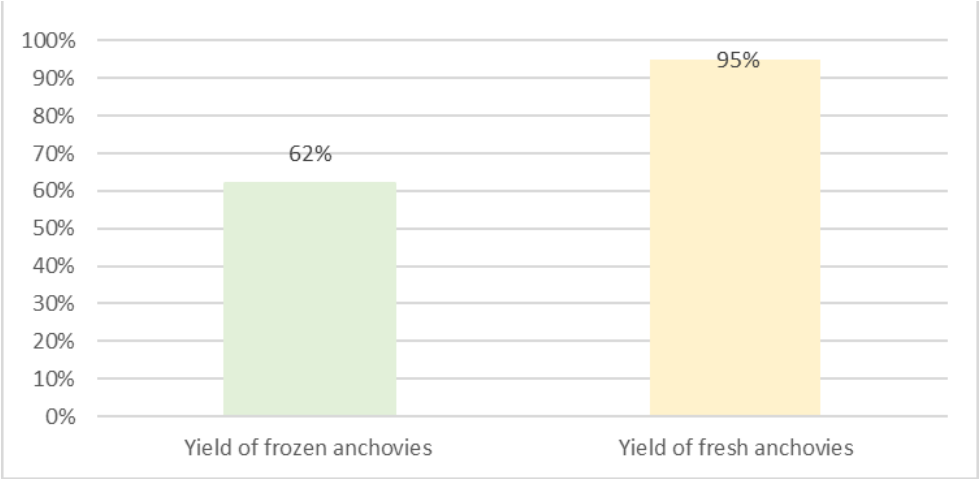


Figure 21: Comparison of yield of fresh and frozen anchovies

The rate of co-products from fresh fish is very low compared to that of frozen anchovies with a significant yield that will be translated into terms of gain for society. In order to resolve this discrepancy, we proceeded to the problem-solving approach based on the principle of continuous improvement (PDCA). This method is used to detect the root cause and implement countermeasures. (Realyvásquez-Vargas et al., 2018)

3.3.3 Problem solving approach according to the PDCA method:

- **Plan:**

➢ Introduce the problem and set goals:

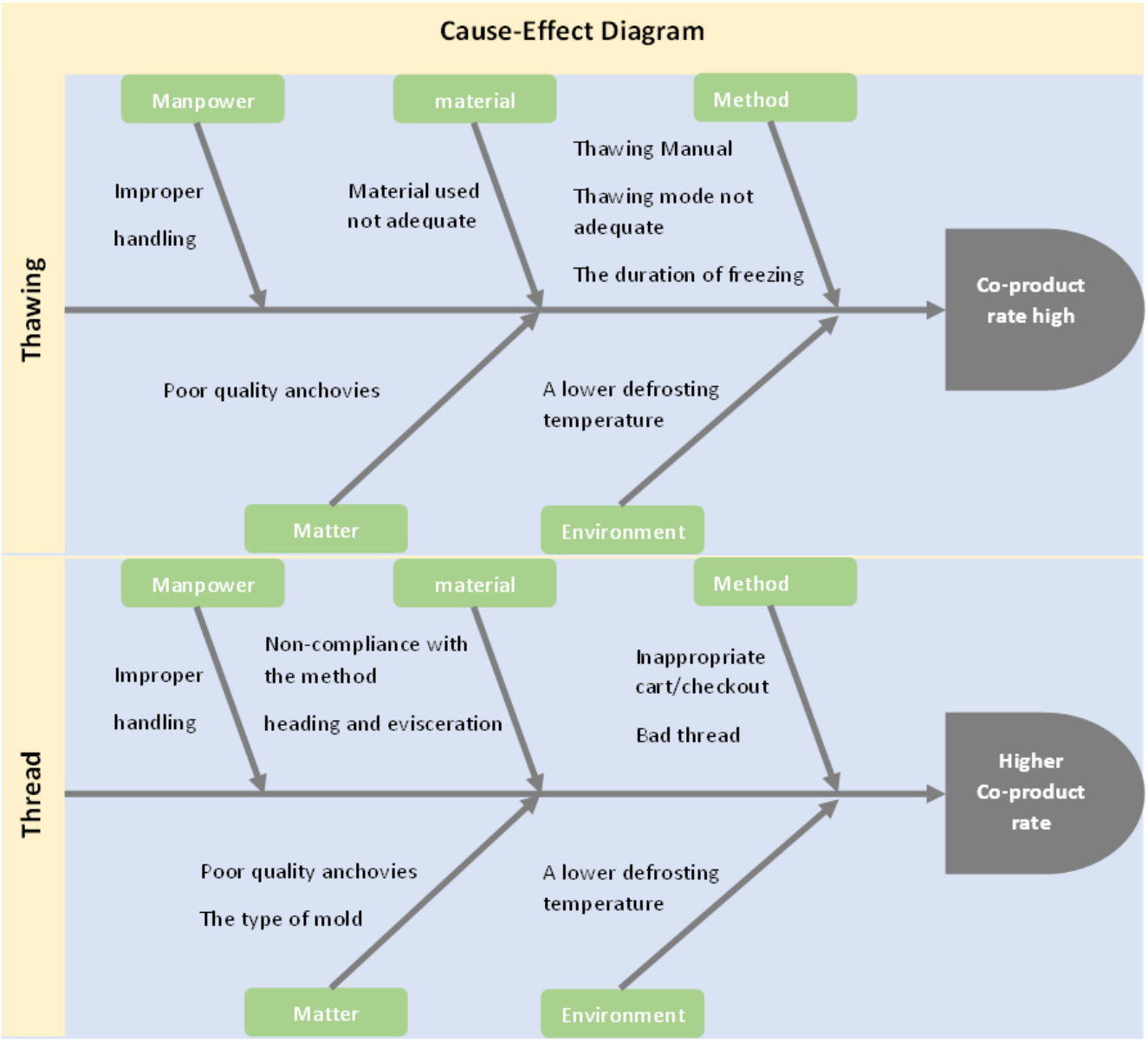
To introduce the problem and set objectives to be achieved, we used the 5W1H method. illustrated in the following table:

Table 23: The 5W1H method for introducing the problem and setting the objectives. (Own construction)

5W1H	The problem	Setup goals
What	A high level of co-products from frozen anchovies above the set threshold (< 20%).	The rate of target co-products must be < 20%.
Who	Quality Manager, Production Manager	Production manager
Where	Raw material processing area (Freezing and thawing), Threading area and Packaging area	
When	After each step.	Every 1/2 hour after each production step.
Why	Reduce the rate of co-products thereby minimizing production costs. Enhance co-products by manufacturing with new products.	To reduce the rate of co-products and increase the productivity of the company.
How	After weighing the quantity of co-products carried out each day.	– Establish control sheets – Regularly monitor all stages of anchovy processing. – Valuing the rest of the co-products. Raising awareness among workers.

- Causes analysis Ishikawa Diagram:

As described in the manufacturing process, the processing of frozen anchovies passes through several stages the most critical are those mentioned in the following table in analyzing the possible causes behind this problem based on the cause-effect diagram following: (Own construction)



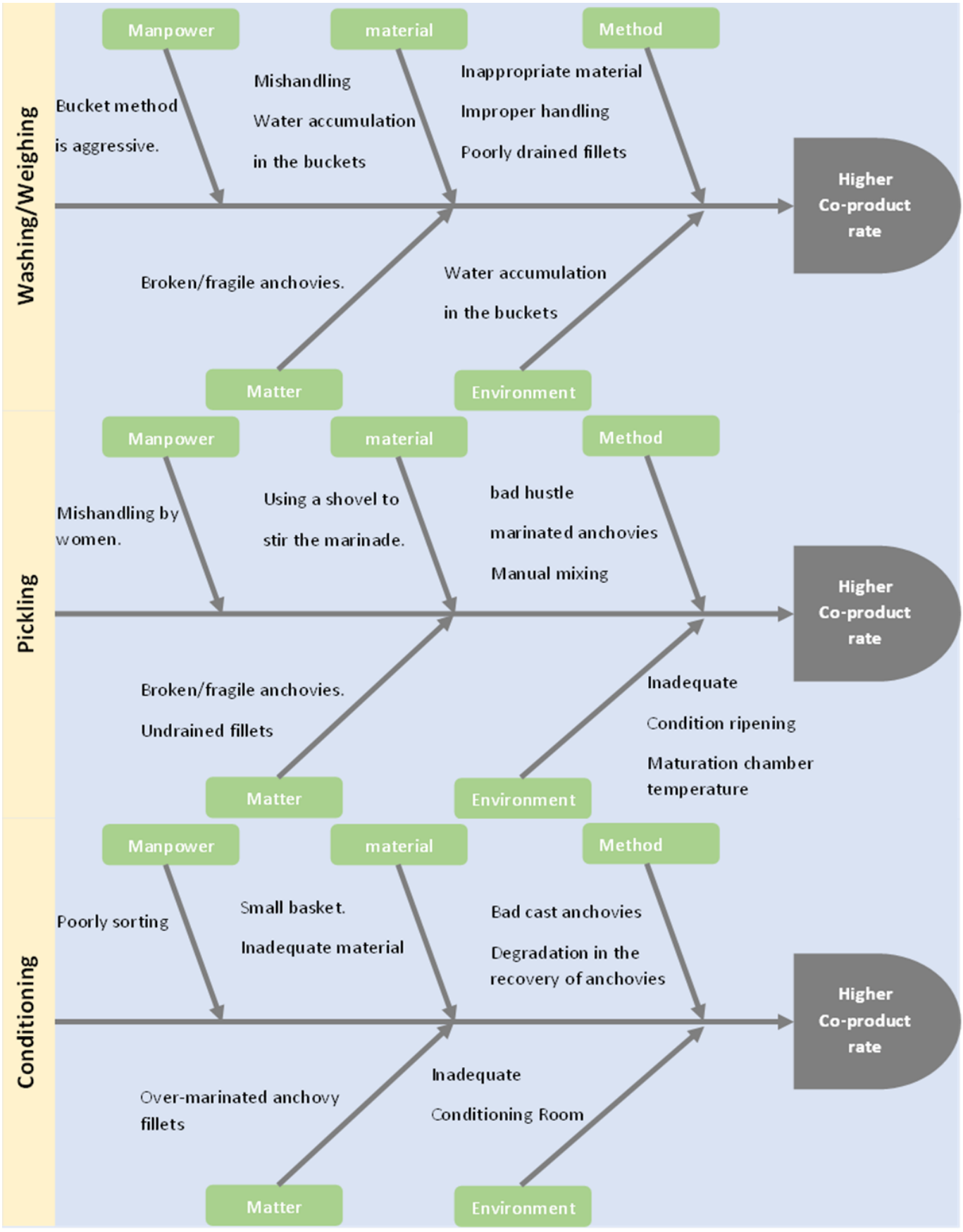


Figure 22: Cause-effect diagram for root cause analysis (own construction)

➢ Selection of main causes

- Workshop 5 Whys:

The 5 whys are a very effective way to find root causes. A 5 whys workshop was conducted (Appendix IV) during the defrosting stage to identify the main causes behind our problem. This workshop made it possible to detect manual defrosting as the root cause that must be treated. After analyzing the possible causes of the increase in the rate of co-products, we proceed now to a selection of the main causes that must be worked on in order to minimize this rate: (Jang et al., 2005)

Note: from 1 to 3:

Table 24: Causes Selection Matrix (Own construction)

Ladder	Relevance	Ease of processing	Easy to detect
1	Irrelevant	Very easy to process	Very easy to detect
2	Relevant	easy	easy
3	Very relevant	Difficult to treat	Difficult to detect

Table 25: Causes Selection Matrix Criteria (own construction)

Process	Choice criteria / Main cause	Relevance	Easy to process	easy to detect	Total
		Weight: 1	Weight: 2	Weight: 3	
Defrosting	Manual defrost	3	2	3	16
	Long freezing time	2	2	2	12
	Unsuitable defrost mode	3	3	2	15
	Poor quality of received anchovies	3	1	1	8
	Material used not adequate	2	1	2	10
	Mishandling by hands	3	2	1	10
Thread	Improper handling	3	1	2	11
	Non-compliance with the method of heading and evisceration	3	2	1	10
	The type of mold	1	1	2	9
	Bad thread	3	2	2	13
	The way of basketing anchovies not adequate	3	1	1	8
	Bad method of gutting and heading	3	2	1	10
	Poor quality anchovies (broken)	3	2	1	10
Weighing/wash	Unsuitable weighing equipment	2	2	2	12
	Mishandling by hands	3	1	1	8
	Broken/fragile anchovies	2	2	1	9
	Bucketing method is aggressive	3	1	2	11

Pickling	Using the shovels to stir the marinade	3	3	2	15
Conditioning	Poorly sorting	3	2	2	13
	Degradation in the recovery of anchovies	3	2	2	13
	Bad distribution of anchovies	2	3	2	14
	Small distribution basket	3	2	1	10

- Pareto chart:

Based on the data in the (table 25) above, we have detected the probable causes that generate this high rate of co-products. We will then select the main causes by the graphical presentation of the Pareto diagram as it is presented in the graph following:

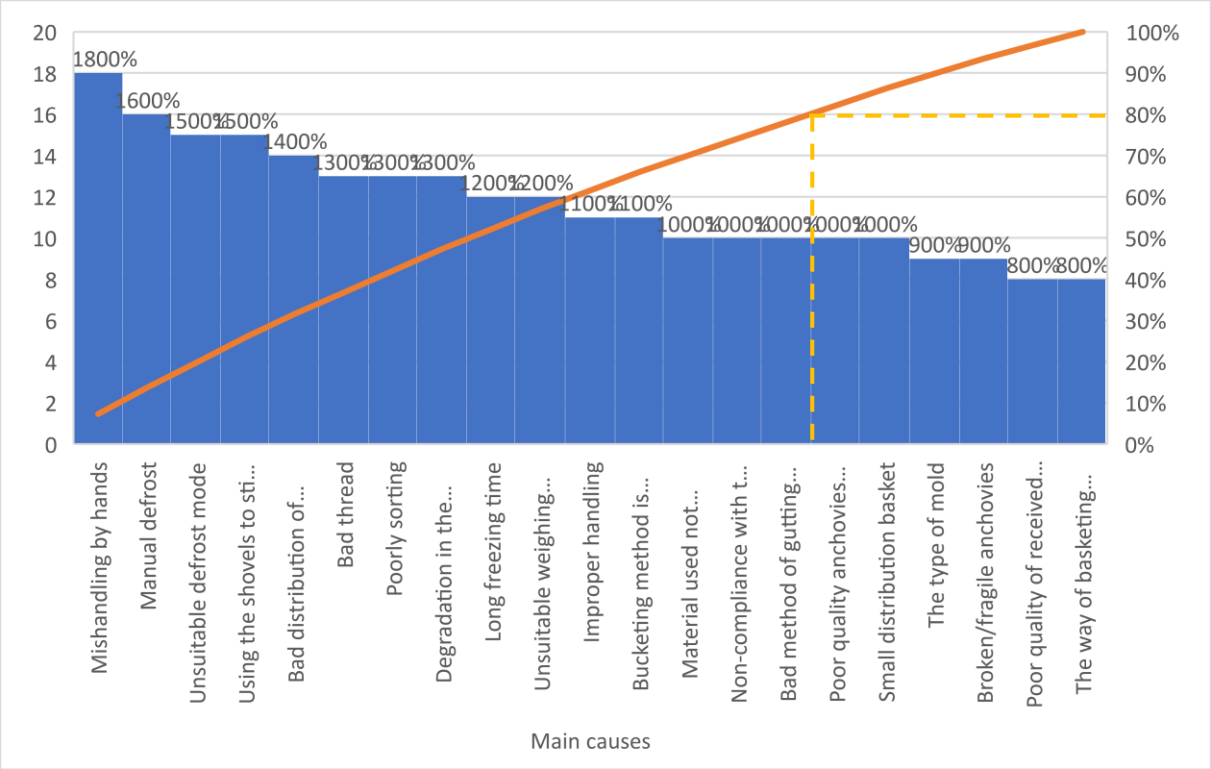


Figure 23: Pareto: Classification of main causes

The graph above shows the main causes that generate 80% of the rate of co-products.

- **Proposed solutions:**

After detecting the main causes behind this observed problem, we propose solutions that can be carried out immediately and there have been those that take time and that require investment: Selection of solutions via the decision matrix:

Table 26: decision matrix (Own construction)

	Speed of implementation	Ease of setting up	Cost	Efficiency
1	Not fast	Hardly easy	Cheaper	Not efficient
2	Fast	Easy	expensive	Effective
3	Very fast	Very easy	Very expensive	Very effective

The weight:

- Speed of implementation: 1
- Ease of implementation: 2
- Cost: 3
- Efficiency: 4

Table 27: selection of solutions (Own construction)

	main cause	Choice criteria / Solution	Speed of implementation 1	Ease of implementation 2	Cost 3	Efficiency 4	Total
Defrosting	Manual defrosting with long freezing and thawing time	Invest in an automatic defroster	1	1	3	3	**24**
	Unsuitable defrost mode	Trick boxes of anchovies into tubs of water under a continuous stream of water	3	3	1	3	21
Thread	Bad method of gutting and heading	Standardize a method that will be feasible and easy and that does not affect the quality of the anchovies	3	3	1	3	**24**
Weighing/washing	Unsuitable weighing equipment	Change the weighing baskets and weigh the crates directly and then pour them into the buckets	3	2	2	3	23
Pickling	Using the shovels to stir the marinade	install an automatic stirring system (bubbling)	1	1	3	3	**24**
Conditioning	Poorly done sorting	Standardize worker basket control sheets	3	3	1	3	**24**
	Degradation in the recovery of anchovies						
	Bad distribution of anchovies	Install conveyor belts to distribute the anchovies	2	1	3	3	22

- **Do:**

➢ **Implementation of solutions**

Among the solutions adopted:

- Leave the boxes of anchovies in tubs of water under a continuous stream of water.
- Put control sheets (Appendix III) at the filleting level of the anchovies to check the way in which the workers do the heading, gutting, and tailing and see if it affects the quality of the anchovies and standardize a method afterwards.
- Change the weighing baskets we weighed the crates directly and pour them by the rest in the buckets.
- We also contacted a supplier of defrosting machines who is located. in Agadir and who offered us a thawing machine with the following characteristics:
    - ✓ Thawing machine with washing system and recycling of water.
    - ✓ Defrosting capacity: one ton per hour.
    - ✓ Price: 150000 DH ≃ 13629 EUR

(Inox, 2023)

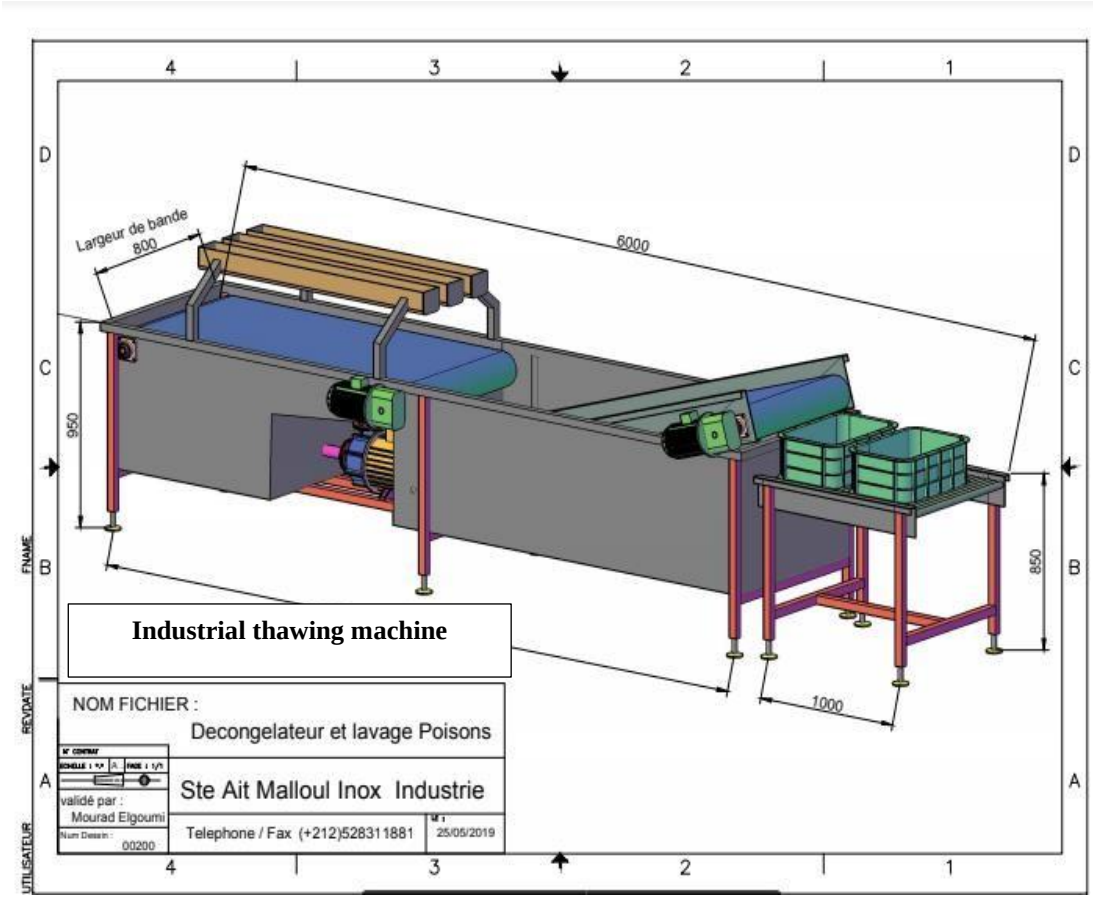


Figure 24: industrial thawing machine

According to this method of problem solving we have found that defrosting constitutes 80% of the root causes. This is why we will detail the process of defrosting how it happens by giving the possible defrosting modes. The choice of a thawing method depends on a large number of factors related to both the characteristics of the product in the frozen state (species, shapes, dimensions, whole, fillets, in blocks, etc.) and its final destination (immediate, deferred consumption, re-freezing, processing).

- **Thawing**

To enable the canning industry to address supply shortfalls in fresh fish and to continue its activity beyond the seasonal fishing campaigns Manufacturers have been using frozen products for many years now (9).

Frozen products do not behave like sterilized preserves, because the action of the cold does not have the effect of destroying all the microorganisms but only of inhibiting their development; that at the time of defrosting, foods can deteriorate as quickly as the same foods simply refrigerated placed under similar conditions of temperature ; that with regard more particularly to marine animals, the flora which naturally contaminates develops perfectly at positive storage temperatures. It follows that the process adopted must reconcile two apparently contradictory imperatives: rapidity of the operation and maintenance of a positive temperature as low as possible. Thawing is a rather complex operation due to the evolution of the properties thermal or electrical properties of the material in question, which vary as the melting of ice.

- ✓ Thawing mode

Thawing with water:

Thanks to its better conductivity, water makes it possible to speed up defrosting operations, but does not eliminate all the disadvantages due to the increase in microbial flora. Its use avoids dehydration but can lead to a deterioration in quality by leaching of certain constituents. Several systems are in use: either by immersion or by aspersion.

By Immersion:

The product to be thawed is directly immersed in a stream of water maintained at + 10 + 12°C. The installation can work in lost water or in a closed circuit with recycling and medium temperature control. In systems operating in a closed circuit, the de-freezer necessarily comprises two different elements: a tank which contains the product to be thaw and an exchanger to maintain the water at the desired temperature.

Sprinkling:

Sprinkling can be done in various ways and lends itself quite well to mechanization. She can be static when the products, contained in crates or baskets, are arranged on an inclined plane and receive water from showers located directly above.

- **Check:**

➢ **Check the results and correct:**

The actions taken are carried out during the months of April and May and they have given as rate of co-products the following table:

Table 28: Rate of co-products after problem solving (own construction)

Month	Chunk rate	Yield of frozen anchovies
December 2022	26%	82%
January 2023	19%	

The following (Figure 25) represent the Comparison of the yield of frozen anchovies before and after problem solving

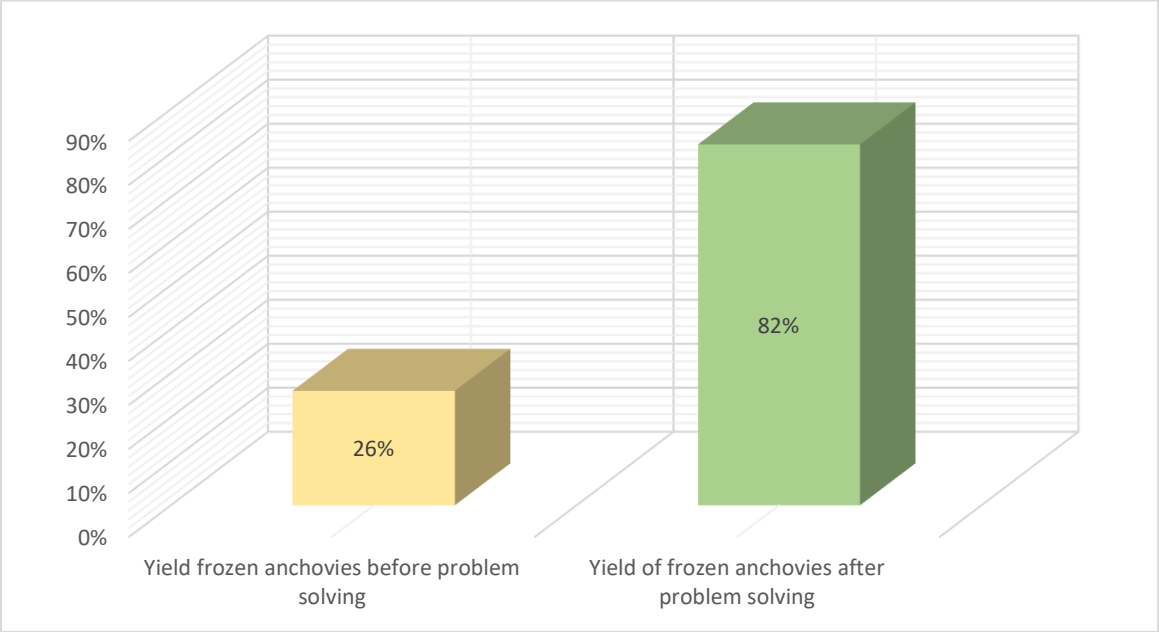


Figure 25: Comparison of the yield of frozen anchovies before and after problem solving.

- **Act :**

➢ **Standardize:**

All of the control sheets drawn and set up to ensure the follow-up of causes behind this problem and reduce the rate of co-products.

➢ **Extend:**

What ?
Solutions aimed at better reducing the rate of co-products.

Who?
The production manager and his managers

Why?
To reduce production costs and fight against waste.

When?
May's beginning

How?
Start with the control sheets developed while waiting for the application of the other solutions.

Where?
In the reception, filleting and packaging areas.

Figure 26: Extend solutions. *(own construction)*

3.3.4 5S project (Reorganization of the Maintenance area):

The maintenance area is full of spare parts, each as heterogeneous as the others, generally arranged in inappropriate ways, they litter the ground, obstruct the movements of operators, block passages, and risk creating confusion. The photos below illustrate the condition of the maintenance area before and after implementation of the 5S Worksite. (Michalska & Szewieczek, 2007). (Sharma et al., 2019)

Table 29: Photos of the maintenance workshop before and after the 5s Worksite (own construction)

Picture before	Picture after
	
Undefined cabinet location with misplaced and unidentified spare parts.	Delimitation of an area for the location of the cabinet and identification of spare parts with a labeling system.
	
Undefined bin location with clutter of unnecessary tools.	Get rid of unnecessary tools and floor tracing for the location of the trash can.
	
A bad location of the desk with clutter of papers and useless space with bad paint.	Tidying up the office and re-painting the walls and cleaning the floor.

- **Tracking of 5S audits:**

During the implementation of this project, tracking audits were organized during the month of January via 5S checklists (Appendix VI) to ensure the effectiveness of the 5S method. According to audits before and after their implementation, the results found are presented in the table following:

Table 30: Results of the audits before and after the 5s Worksite (own construction)

	Before 5S		After 5S	
5S	% yes	% no	% yes	% no
Rid	50%	50%	80%	20%
Tidy	10%	90%	90%	10%
Clean	20%	80%	70%	30%
Standardize	20%	80%	80%	20%
Perpetuate	0%	100%	90%	10%

The following (Figure 27) and (Figure 28) represent the comparison between before and after applying 5S on the maintenance workshop

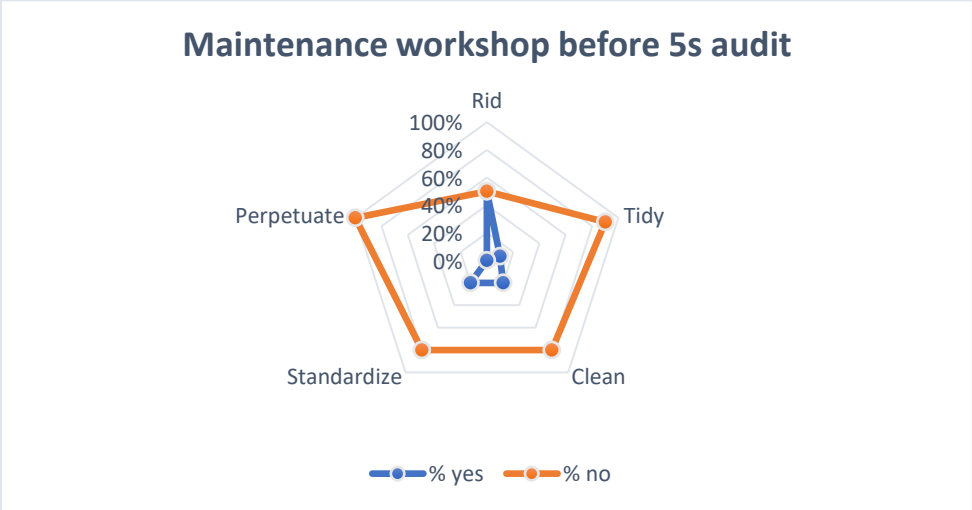


Figure 27: Maintenance workshop before 5s audit

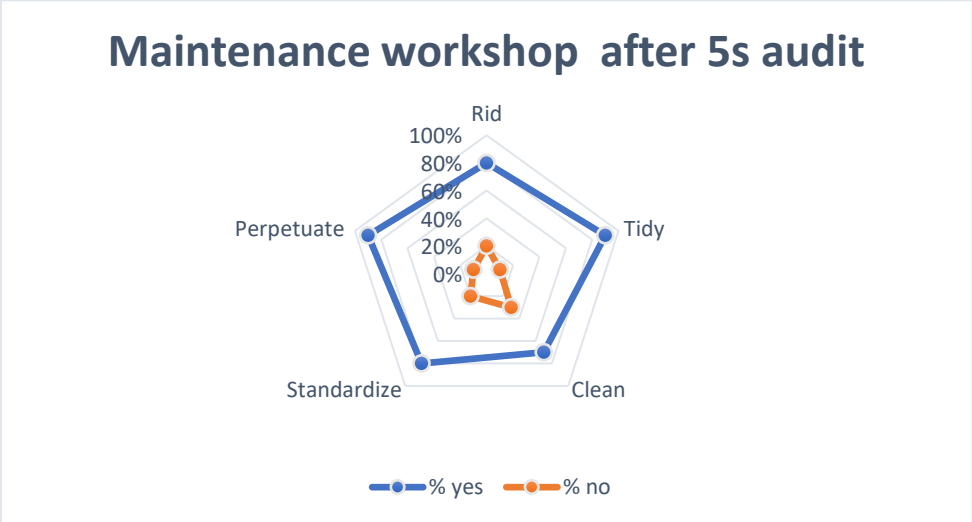


Figure 28: Maintenance workshop after 5s audit

According to the previous results, the 5S method has generated gains including the organization and layout of the maintenance workshop in order to create a better environment. working conditions as well as the ergonomics and safety of operators.

3.3.5 Implementation of a Kanban system:

To avoid waste due to waiting either for production or for raw materials between packaging and sealing process, Kanban system which is based on the calculation of a number of units needed to produce or manufacture. We calculated the number of Kankan according to the formula described previously and we obtained the following results: (Kotani, 2007)

Table 31: Kanban number calculation (own construction)

Process	Threshold	Average consumption	Replenishment lead time	Safety stock	N: container capacity	Kanban number
Conditioning	1 kanban	1500 kg/h	1h	210 kg	210 kg	**9 Kanban**
Sealing	3 con-tenants	810 Trays/ hour	0.016 h	3 Trays	10 trays	**4 Kanban**

- In packaging, 9 Containers are needed.
- And in sealing it will take 4 Kanban each contains 10 trays to avoid waiting at this stage.

3.3.6 Standardization of the anchovy processing process:

- **Introduction**

standardizing work is a prerequisite for performance and continuous improvement. The variability of operators has many negative consequences in terms of time, quality and costs. Standardization reduces process variability. (10) Standardized work is the most efficient operating mode for the execution of tasks:

- To deliver a product or service in complete safety with the performance required in quality, cost and productivity.
- The reflection of the state of the art concerning the conditions of execution.

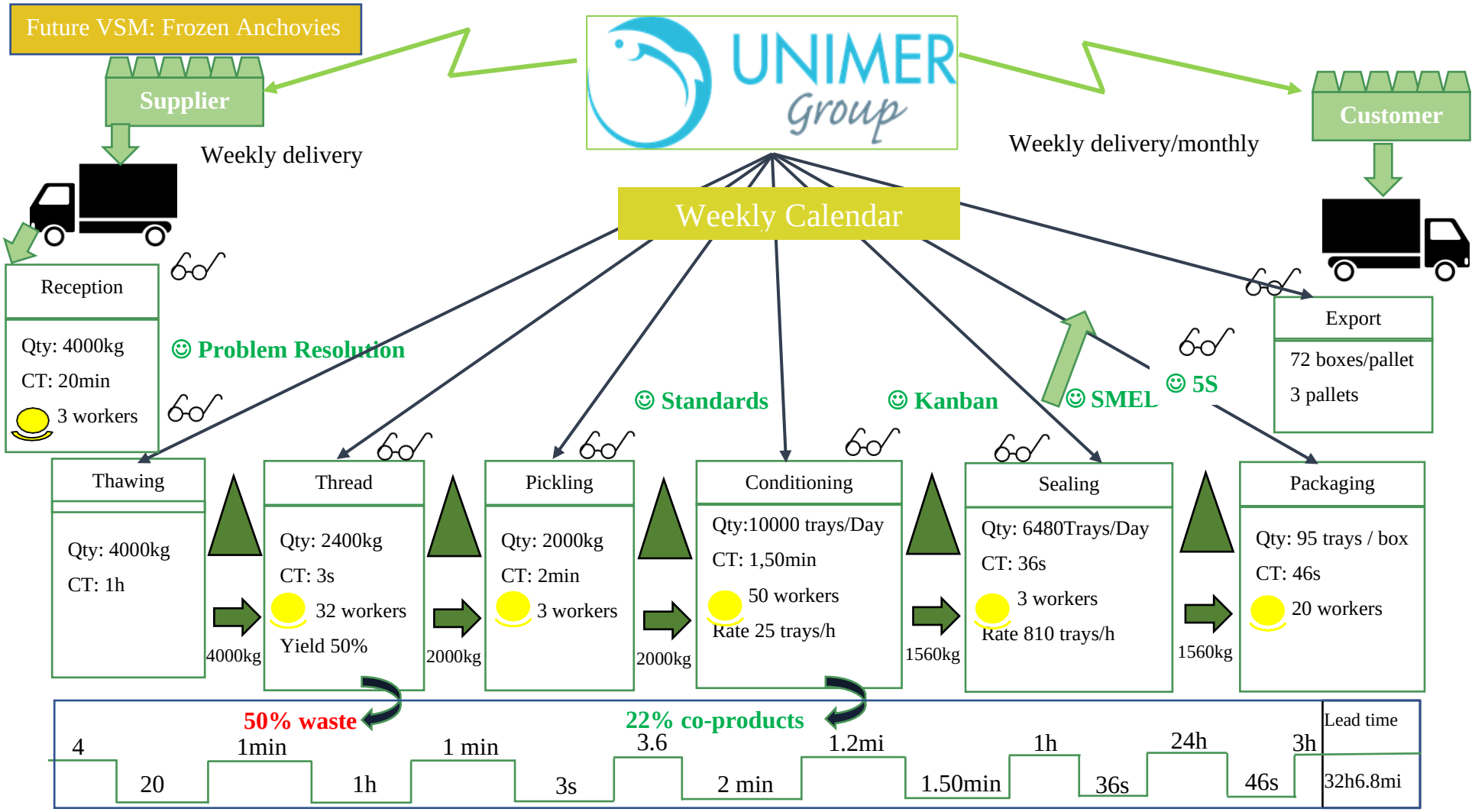
- **Standardization of the manufacturing process:**

In the problem solving method, working on the possible causes behind the high rate of co-products, the manual method of processing anchovies was not adequate, that either in the filleting, marinating or

packaging stage. Each of the operators had her own way of working. Some make significant losses, others less this variation in methods could influence the profitability of the company and cause a decrease in their performance, hence the need to establish standards aimed at describing the work steps and all the actions that the operator must follow to complete a task. This standardization makes it possible to standardize the parameters in order to obtain at each repetition the same results, to minimize the variations introduced by the operators and to eliminate their unnecessary movements. As a corollary to this, it will be possible to reduce waste, facilitate problem solving, thus guaranteeing the repeatability of the performance of operations and consequently a continuous improvement in productivity. Standards have been set in place for the various stages of anchovy processing (Appendix V).

3.3.7 Drawing of the future mapping of VSM flows:

Solutions are offered to improve business productivity, eliminate waste, standardize the process. The tools we have treated have generated a gain time and quality. We will draw the future flow mapping for frozen anchovies, to illustrate the interest of the methods we have applied in reducing the lead time.



Caption:	Quantity processed: 26000 Trays
Product: Marinated anchovy fillets	Drained Weight: 60g
Packaging reference: BELMONTE	Number of trays produced by the quantity of anchovies: 1560000g/60g= 26000 trays=273 boxes=4 pallets

Figure 29: Future VSM chart of Frozen Anchovies: ***Own construction***

In this future mapping, all improvement actions to reduce the rate of wastes, were implemented. And we find that the processing cycle time of frozen anchovies decreased after the introduction of the problem-solving project. we have both reduce the rate of co-products by up to 22% and the defrosting time if the company chooses to invest in an industrial thaw, its productivity will increase over time.

- **Conclusion:**

The implementation of Lean manufacturing in the production line has enabled development at the production level and an improvement in the various performance indicators. The SMED influenced the OEE of the machine because the change of mold constitutes a part machine stops, thus minimizing this time. The problem solving allowed to reduce the rate of rejects (co-products) thus, we have tried to propose improvements throughout the entire production chain. The implementation of standards has made it possible to standardize practices between operators.

Conclusion

During this thesis project, we had the opportunity to deal with a subject that is one of the main concerns of any company, namely the control and optimization of flows and processes. In this regard, the study carried out is part of the implementation of Lean Manufacturing in a production line for marinated anchovy fillets, with a view to remedy the problems of waste that emanate from the production process, in order to achieve the required level of performance.

First, we started with a general presentation of the host organization UNIMER, in order to explore both the organization and its operating principle. Thereafter we continued with a presentation of the concept of Lean Manu invoicing in order to show the need for society to establish such an approach which aims to improve performance by taking into account customer satisfaction.

We started our project with a diagnosis of the current situation. Carrying out the flow mapping of the current state allowed us to reveal any kind of waste influencing the activity of the company. The calculation of indicators (OEE, MRT, Takt Time, Scrap rate) helped us to have an idea of the level of performance of the processes of production.

The analysis of these data, as well as the active observations that we carried out, allowed to reveal the most important causes that cause the problems detected, and which represents the main wastes that punctuate the production process, such as inappropriate series changes, waiting between processes, unnecessary trips, as well as than other operations without added value resulting from organizational shortcomings and which represent the majority sources of waste.

And at the end of this analysis, improvement actions were launched such as the Kanban system which will allow production to avoid waiting between processes and supply with the necessary quantities. Also, the strengthening of the “5S” culture and the implementation of this approach

within the maintenance area which represents the area which materials and spare parts necessary for repair in the event of a technical problem with the machine and other equipment. This allowed us not only to improve productivity but also to motivate operators and promote their conditions of work.

In order to reduce the series changeover time of the sealing machine, we have proposed the realization of a SMED site which allowed us to quickly change the mold with the elimination of non-value-added shares. So, we were able to reduce the time change of series from 40 min to 25 min. And the establishment of standards to sustain the SMED practice. Without forgetting the problem-solving approach in order to reduce the rate high co-product

General conclusion

Lean manufacturing focuses on eliminating wastes during production cycles by combining sets of improvement tools and a culture shift among employees. By practicing Lean manufacturing, companies can effectively shorten production time, eliminate unnecessary inventory, maintain the highest quality of production, minimize underutilization of staff, and enhance autonomy among production teams. In return, the company achieves better returns on its investment.

As impressive as it is, few companies implement Lean manufacturing programs the right way. Several difficulties inhibit the success of these programs, from logistical and planning challenges to behavioural concerns.

Some practical advice to successfully implement the lean management tools:

We need the support from senior management, as well as providing the necessary training for the staff, because some companies have limited workforce, and lack of appropriate tools thus they need to provide continuous training for the management staff and all the employees. It is also important to have sufficient performance data, the Lean management implementation is based on the inputs provided during the data collection thus those data must be reliable and precise.

Implementing several changes at one go is not a good idea, we need to focus all the efforts on one area and issue to solve it, better solving one issue than nothing. established work practices (cultures) Focus on a Culture Change at All Levels of the Organization.

RECOMMENDATIONS

UNIMER company, must ensure the automation of the entire process by investing in new equipment to improve the productivity. The implementation of these approaches mentioned above constitutes a higher support permanent management and an essential prerequisite for the implementation of other concepts which require a rigid infrastructure, such as the just-in-time production system and the TPM (total productive maintenance). As a condition for the sustainability of the proposed improvement levers, it is necessary to maintain performance monitoring, and ensure the deployment of 5S on a daily basis, In addition, it is necessary to train operators on continuous improvement and standard operating procedures.

On a personal level, Thesis allowed us in addition to discover the managerial and strategic dimension of the engineering profession. It is an experience that allowed us to integrate the professional world, to learn a lot on the relational level within a well-structured society and above all to collaborate with people with different skills and cultural levels. These acquired skills during the thesis will be an essential tool for integrating the business world as a SC manager.

SUMMARY

The company UNIMER, like many other agri-food companies, continuously works to implement a continuous improvement system to achieve efficiency in daily life, which is where this thesis project fits. The company's goals include meeting and exceeding the customer's expectations in terms of quantity and delivery time as well as to increase productivity.

Lean manufacturing aims to increase productivity and match customer expectations by decreasing non-value-added activities and eliminating waste. This serves as the project's goal. An exploratory investigation was carried out in attempt to achieve this. It includes measuring productivity and OEE (Overall Equipment Effectiveness) in order to assess the performance level, as well as describing the processes using the VSM.

The primary concerns affecting productivity have then been highlighted through data analysis, including challenges with work ergonomics, incorrect series modifications, and high co-product rates. The next stage is to offer suitable remedies to those problems. These remedies include the following:
SMED (Single-minute exchange of die) implementation is being done to shorten the time between serial updates. Methods for resolving issues (PDCA). the implementation of a "5S" programme to organize the workplace and enhance working conditions. besides the Kanban system. The Kaizen principle has room for development still.

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APPENDICES

Appendix I: Customers order

Appendix II: OEE monitoring sheet.

Appendix III: Thread monitoring sheet.

Appendix IV: SMED Standards

Appendix V: 5s Checklist

Appendix VI: statement on consultation practices

Appendix VII: declaration on authenticity and public assess of final master's thesis

Appendix I: Customers order

Table 32: Customers Order

CLIENT	FISH	TYPE	REFERENCE	TRAYS	INGREDIENT	FILM	QUANTITY
RR1	Fillet	anchovies with vinegar	BELMONTE	BLACK	Garlic	MB	12000
RR1	Fillet	anchovies with vinegar	BELMONTE	WHITE	Garlic	MB	12000
RR1	Fillet	anchovies with vinegar	BELMONTE	TRANSPARENT.	Oil	MB	3600
RR1	Mariposa	anchovies with vinegar	Vanelli	WHITE	Oil	Couvercle	3000
RR1	Fillet	anchovies with vinegar	Vanelli	WHITE	Oil	Couvercle	5000
RR1	Fillet	anchovies with vinegar	Fiorito	WHITE	Garlic	Couvercle	1000
RR1	Fillet	anchovies with vinegar	calderos	WHITE	vinegar	Couvercle	1000
RR1	Fillet	anchovies with vinegar	Monegasque	WHITE	vinegar	Couvercle	2160
SD1	Fillet	anchovies with vinegar	BELMONTE	WHITE	Garlic	MB	30000
SD1	Fillet	anchovies with vinegar	Fiorito	WHITE	Garlic	Couvercle	10000
SD1	Fillet	anchovies with vinegar	Fiorito	WHITE	Oil	Couvercle	5000
SD1	Fillet	anchovies with vinegar	Fiorito	WHITE	Garlic	Couvercle	10000

Appendix II: OEE monitoring sheet.

Table 33: OEE Tracking sheet.

	OEE Tracking								
Date	**Ref**	**Opening time in minutes**	**Break time**	**Theoretical Machine Capacity/Hour**	**Production /days**	**Nbr of non-compliant product**	**Good part production**	**Realizable theoretical production**	**OEE**

Appendix III: Thread monitoring sheet.

Table 34: Thread monitoring sheet

UNIMER Group	Contrôle Filetage	Code Version 00

Date : 28/04/2023. Lot : .....

Moule/produit : KK-60.....

Heure	N° Table	N° Caisse /Panier	Noms ouvrières	Filets		Observations
				Conforme	Non conforme	
8:30	04	01	- Achnaka - Nkaira	✓		RAS
9:00	04	02	- Said - Satih	✓		RAS
9:30	04	03	- Nahou - ELHouti	✓		RAS
10:00	04	04	- Herbani - Ti3jmout.	✓		RAS
10:30	03	01	- Sehli - Abid	✓		RAS
11:00	03	02	- Tirdah - Aitouchti	✓		—
11:30	03	03	- Abouair - Achehroun	✓		—
12:00	03	04	- Satih. - Said	✓		—
14:00	02	01	- Bouchrab - Nouni	✓		—
14:30	02	02	- Sahli - Abid	✓		—
15:00	01	01	- Khayrat - Aouni	✓		—
15:30	01	02	- Azzi - ELHouti	✓		—
16:00	02	03	- Nellali - Aitouchki	✓		RAS
16:00	02	04	- Tirdah - Aitouchti	✓		RAS
17:00	04	02	- Satih - Said	✓		RAS

Fréquence : chaque ½ heure

Appendix IV: SMED Standards

Table 35: SMED Standards

Step	List of actions to realize			Pilot: Yassine EL HADIRI
	Task description	Key points	Illustration	MRT
01	Stop the machine	Check the availability of the toolbox before the start of change		2s
02	Supports arrangement			90 s
03	Dismantle the rails	Change of rails according to the article		100 s

04	Remove the lids from the molds		 	2 s
05	Remove the 4 bolts attached to the top mold			20 s
06	Change and adjustment of the film			30 s
07	Separate the upper mold from the lower mold	Pay attention to the upper mold which is hot	 	3 s

08	Dismantle the lower mold		 	400 s
09	Remove the red plates from the lower mold	Provide a cabinet to put the disassembled mold and the red plates	 	30 s
10	Dismantle the upper mold	Be careful and wear heat resistant gloves	 	100 s
11	Assemble the lower mould, put the red plates and fixing the bolts		 	90 s
12	Adjusting and securing joints			25 s

13	Assemble the upper mold			1 s
14	Closing of the two molds			3 s
15	Turn on the resistors and wait for the machine temperature to increase to 200°C			560 s

Appendix V: 5s Checklist

Table 36: Checklist 5S (own construction)

UNIMER Group	Checklist 5S		Area : Maintenance workshop
			Pilot : Yassine EL HADIRI
S 1 : Discard	Yes	No	Observations
Absence of unnecessary components in the workstation	*		
Absence of waste in the area	*		
Absence of unnecessary tools in the parts cabinet	*		
Existence of useful equipment (tools, document,)	*		
S 2: Tidy			
the locations of all equipment are traced (adhesive tape)	*		
All components are in identified locations	*		
No human effect on the workstation	*		
All documents are in their places	*		
S 3 : To clean			
Total absence of waste in the area	*		
Absence of dirt on the workstation	*		
No dirt on the floor	*		
Absence of dirt in storage boxes or containers	*		
S 4 : Standardize			
The area has a 5S sign	*		
Any object its designated location	*		
Prioritize visual management	*		
the staff are aware of the instructions	*		
S 5 : Perpetuate			
Action plans are tracked and up to date	*		
Audit the area on a regular basis	*		

Appendix VI: statement on consultation practices

STATEMENT ON CONSULTATION PRACTICES

As a supervisor of Abdelmajid Jamane (Student's name) LJUMGR (Student's NEPTUN ID), I here declare that the final essay/thesis/master's thesis/portfolio[1] has been reviewed by me, the student was informed about the requirements of literary sources management and its legal and ethical rules.

I recommend/don't recommend[2] the final essay/thesis/master's thesis/portfolio to be defended in a final exam.

The document contains state secrets or professional secrets: yes no*[3]

Place and date: Gödöllő, 2023 year 05 month 01 day

Internal supervisor

[1] Please select applicable and delete non-applicable.
[2] Please underline applicable. [3] Please underline applicable.

Appendix VII: declaration on authenticity and public assess of final master's thesis.

DECLARATION

on authenticity and public assess of final essay/thesis/mater's thesis/portfolio[2]

Student's name: Abdelmajid jamane
Student's Neptun ID: LJUMGR
Title of the document: Master's thesis
Year of publication: 2023
Department: Institute of Agricultural and Food Economics, Supply Chain Management Master Programme, Department of Agricultural Logistics, Trade and Marketing

I declare that the submitted final essay/thesis/master's thesis/portfolio[3] is my own, original individual creation. Any parts taken from an another author's work are clearly marked, and listed in the table of contents.

If the statements above are not true, I acknowledge that the Final examination board excludes me from participation in the final exam, and I am only allowed to take final exam if I submit another final essay/thesis/master's thesis/portfolio.

Viewing and printing my submitted work in a PDF format is permitted. However, the modification of my submitted work shall not be permitted.

I acknowledge that the rules on Intellectual Property Management of Hungarian University of Agriculture and Life Sciences shall apply to my work as an intellectulal property.

I acknowledge that the electric version of my work is uploaded to the repository sytem of the Hungarian University of Agriculture and Life Sciences.

Place and date: 2023/05/01

Student's signature

[2] Please select the one that applies, and delete the other types.
[3] Please select the one that applies, and delete the other types.