POLITECNICO DI TORINO

Master of Science in Engineering and Management

ANALYSIS AND OPTIMIZATION OF THE TOOLS FOR THE PERFORMANCE EVALUATION OF THE PRODUCTION LINE OF ICE CREAMS

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Introduction

The present thesis was drafted during the internship conducted in collaboration with GROM, the italian ice-cream company, in its production site located in Mappano (Turin). Its objective is to explain the work done in two months aiming to implement new tools for the production performance evaluation according to the company needs.

In the first chapter a brief presentation of the company is present, starting from the foundation and including a description of the wide range of products sold.

The second chapter contains an explanation of the theoretical concepts of the World Class Manufacturing and the importance of the KPIs as measures of efficiency of the factory. Especially focusing on the Overall Equipment Efficiency and the Output Reliability.

The work continues with a detailed presentation of the production site, describing how the manufacturing process takes place and how the data about the production are collected. There is also a presentation of the current performance evaluation systema used and the criticalities found in there.

The fourth chapter is the core of the paper, in which are explained the modifications and the new introductions made. The first section focuses on how the current local system was improved by using the programming language in Excel to implement new functions. The second one concerns the creation of a dashboard to sum-up and better visualize the results obtained in the previous file.

Lastly, the results achieved are described also with suggestions about new projects that could be useful to further improvements.

1. The company

Gromart s.r.l. - best known as GROM - is an italian company specialized in the production of premium ice-cream. Its production plant is based in Mappano of Caselle (Turin) and it owns more than 50 ice-cream shops all over the world, of these 40 in Italy. Its successful feature is the high quality of raw materials to produce ice-cream “like it used to be made”. It also produces ice sticks, biscuits and other packaged products.

1.1 History

GROM was born in 2003 by Federico Grom and Guido Martinetti, who opened their first ice-cream shop in Turin. Their aim was to make the ice-cream like it was made in the past – as it’s possible to read on their sign “GROM - il gelato come una volta” – focusing on the concept of “tradition” and it implies the usage of fresh and high-quality raw materials with no addition of dyes, artificial flavours and emulsifiers. Just few months from the inauguration of the first shop, the brand has spread and the two owners opened new stores both in Turin and in other cities of Italy like Padua, Florence and Parma; in addition to that, the company set up branches abroad, starting in 2007 in New York, followed by shops in France, U.K, China, Hong Kong, Japan and UAE. In 2015 the company was acquired by the multinational corporation Unilever, one of the largest food groups which already owned the Algida and Magnum brands.

In January 2020, there has been an evolution of the business model and the vision projected over the medium and long term, deciding to focus on new opportunities and new channels, aiming at the large-scale distribution.

Even though the shops are located all over the world, the processing of the fresh ingredients occurs in only one plant located in Mappano; this allows to keep exactly the same level of quality and taste in each single store, wherever it is located. Indeed, the products are sent as semi-finished products in the stores where they are stirred and sold to the customers.

1.2 The products

GROM has a wide range of products made of ice-creams, ice sticks and confectionary products. The main ones which are produced in the manufacturing plant are the following (some of those showed in Fig.1):

- Pints. This product can be found in the ice-cream shops, in supermarkets and in some coffee shop. It is a packaged ice-cream made with the same liquid mix intended for the shops, but it already contains the inclusions and is ready to be consumed.
- Pots. It is the same concept as the pints, but in a smaller format. Their production is mainly intended for tourist resorts and seaside locations.
- BOH (Back of house). Ice-cream packages of larger size with than the pints are conceived for hotel and restaurants.
- Ice sticks. Made with simple ingredients such as fresh fruits, sugar and water, they are sold in the ice-cream stores, in the supermarkets and in the cafes.
- Bags. They are the units for the ice-cream shops received in specific plastic bags. Once there, the semi-finished products are stirred and finalized with the addition of the different inclusions according to the flavour.

- Biscuits. This category includes different formats and different flavours; some of them are used as inclusions or toppings for the ice cream, like the “meliga” biscuits, which are stirred in the “Crema di GROM” ice-cream.

Fig. 1 Some of the goods produced in Mappano site; respectively: pint, ice stick and minipot

In addition to them, GROM sells other products (Fig.2), as:

- Gelato sandwich, an ice-cream biscuit and it can be half coated with chocolate cream
- Hot chocolate
- Chocolate bars and pralines
- Milkshakes
- Marmalades and Jams
- Spreads

Fig. 2 Other finished goods sold by GROM, in order: hot chocolate, jam and gelato sandwich.

2. Theoretical concepts

In this chapter will be explained some concepts contained in the literature which will be useful for the comprehension of this paper and for the analysis of the production system.

2.1 World Class Manufacturing

In the recent years, it has become more and more important for the manufacturing industries to thoroughly rethink their production strategies and to evaluate whether they are still adequate to satisfy the constantly rising demands of the international markets of the new millennium.

It is in this context that Lean Manufacturing and World Class Manufacturing find their collocation. They represent two manufacturing strategies that have grown vastly during the last few years, and that have gained a constantly growing number of followers, made up of manufacturing companies that seek a solution to overcome productive difficulties and to be able to compete at high levels on the international market.

World Class Manufacturing originates towards the end of the 1980s in America (the term was invented by Richard Schoenberg in 1986), partly as a response to the achievements of Ohno's manufacturing model in Japan but did not gain success until the beginning of the twenty-first century, when it grew to become what it is today: a widespread production system adopted all over the globe. The terminology "world class" was used to refer to the capabilities developed by American and German companies to compete in international export markets, indicating an unmistakeable tendency to focus on prevailing on all competitors and aiming to become among the best in the manufacturing world.

The WCM arises from the experience gained in the most effective methodologies and techniques to satisfy in the best way the customer needs (high quality products, delivery on time, lowest products costs) as the result of a long journey through decades of manufacturing activity. WCM is a rigorous and integrated production system to uniform all the processes, not only to reduce but to eliminate the waste, improving the quality both of final products and of methodologies, increasing the job safety and reducing the environmental impact, involving all the organization on each hierarchical level.

2.2 WCM application in GROM

Implementation of WCM in Mappano site started in 2019 from the basic principles: using information tables next to the machines, carrying out training courses for all employees based on their duties and responsibilities, with the intent of increasing interchangeability between the workforce as much as possible.

My job during the internship was focused on the application of WCM in Production segment, which aims to remove the variation, standard the process and improve the productivity with faster processes, focusing both on quantity and especially on quality. The initial step, to reach what said before, is to analyse and study the current status of the production line, improving the way the information is collected and used.

Then the goal is to define a role model, setting standards against which others measure themselves: to do so it is necessary to have a transparent, current, and easily available global performance picture that helps to focus on where to improve and deliver value to the business, driving improvements that will enable factory to reach and exceed performance targets. For this reason, Unilever shares with all its factories an internal document in which are meticulously defined all the standards to apply in order to obtain a complete and correct evaluation of manufacturing performance through the KPIs (Key Performance Indicators).

KPIs refer to a set of quantifiable measurements used to gauge a company's overall long-term performance. They specifically help determine a company's strategic, financial, and operational achievements, especially compared to those of other businesses within the same sector. The aforementioned document is named Managing Manufacturing Performance (MMP) Code; it standardises the way the factories are operated and evaluate manufacturing performance with the purpose to have one terminology and one methodology for measuring and reporting manufacturing operations across the firm.

The following paragraphs report the information contained in the MMP Code about those KPIs which are considered the most significant ones in order to represent the targets which should be met by the production line.

2.3 Line time classification

For all reporting, aggregation and consolidation purpose of data, time is a obligatory unit of measurement of KPIs, irrespective of the category. In order to consider accurately the amount of time consumed by a Line, a suitable way to classify time is needed. This classification has to allow sufficient visibility, consistency and accountability to be usable for manufacturing performance management, planning, costing and standard capacity calculation methods.

There are four types of time losses a Line can undergo:

1. Legal losses:

These occur when a machine or Line is unable to produce for legal/statutory/regulatory reasons. Such losses are outside of Unilever's control as they result from, and can usually only be resolved under, the legal jurisdiction of the country in which the Site housing the machine or Line is located.

2. Unutilised Capacity losses:

These are losses incurred when a Line is underutilised or idle; e.g. when it is available for production. An exception to this definition is while an Equipment/Process Trial is being carried out, as an Unutilised Capacity loss is then experienced though an activity is being performed on the machine. The Factory Director and his external or internal business partners are responsible for the management of this loss.

Any decision not to produce will be based on logical factors such as high costs, poor return on investment, business planning or other pre-determined considerations.

3. Process Driven losses:

These occur when a Line is intentionally stopped to complete certain activities on a machine or Line. While these activities are being carried out, the Line is not able to produce.

This means that even if a machine is running for long periods of time, the extent of these losses should be largely consistent.

4. Manufacturing Performance losses:

This is when a Line unexpectedly stops while it is intended to be in production under a launched Production Order. These losses are mostly the responsibility of manufacturing, but there can be exceptions. The magnitude of these losses will mostly depend on the size of the Production Order and the uptime of the machine e.g. the length of time for which the machine has to run.

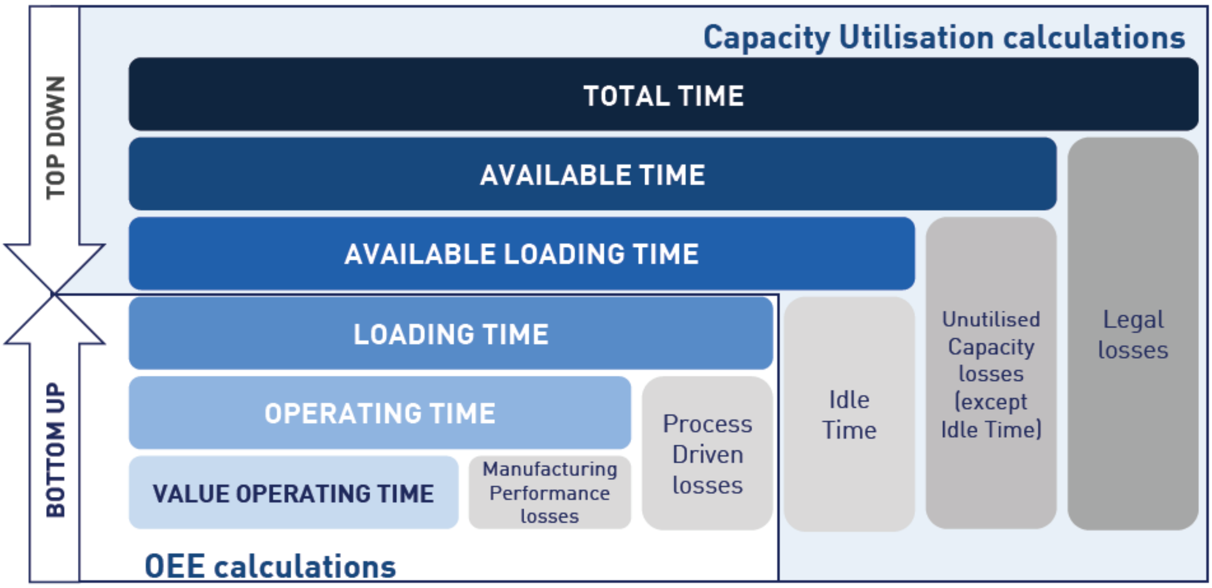


Fig. 3 Scheme describing the time classification and the relative losses

This Time Classification is valid for calculations at annual, quarterly, monthly, weekly, daily and shift level. Then, according to the type and the amount of losses occurred, it is possible to define different time range as schematized in Fig. 3.

Total Time (TT): The absolute number of hours available in a year of 365 days except for leap years (366 days per year)

$$Total\ Time\ (TT) = 365\ \frac{days}{year} \times 24\ \frac{hours}{day} = 8760\ h$$

Available Time (AT): The maximum time for which Unilever could utilise the Line for production during the Total Time. This excludes only the time for which Unilever has no control (Legal losses). This time is highly relevant for Capital Expenditure decisions. Since Unutilised Capacity losses can be reduced over a few months, the Available Time represents time considered as available over the long term.

$$Available\ Time\ (AT) = TT - legal\ losses$$

Available Loading Time (ALT): The maximum time for which Unilever could utilise the Line for production over the short term. This time is used by the production planner for preparing weekly production plans. Since Manufacturing Performance and Process Driven losses can be reduced in a few weeks, Available Loading Time represents time considered as utilisable for production in the short term.

$$Available\ Loading\ Time\ (ALT) \\ = AT - Unutilised\ Capacity\ losses(\ except\ Idle\ Time)$$

Value Operating Time (VOT): The minimum amount of time that will be consumed by the Line for a given Production Plan under ideal conditions (operating at Nominal Speed and without any loss of any kind). It is calculated as

$$Value\ Operating\ Time\ (VOT) = \frac{Good\ Volume}{Nominal\ Speed}$$

Operating Time (OT): The time for which the machine is operating including both uptime (VOT) and failure time (Manufacturing Performance losses).

$$Operating\ Time\ (OT) = VOT + Manufacturing\ Performance\ losses$$

Loading Time: The time for which the machine is loaded, including uptime (VOT), failure time (Manufacturing Performance losses) and activity time (Process Driven losses).

$$Loading\ Time\ (LT) = OT + Process\ Driven\ losses$$

Idle Time: The time for which the machine is not loaded because of lack of demand or capacity being more than demand.

$$Idle\ Time = ALT - LT$$

A practical example is shown in Fig. 4 below

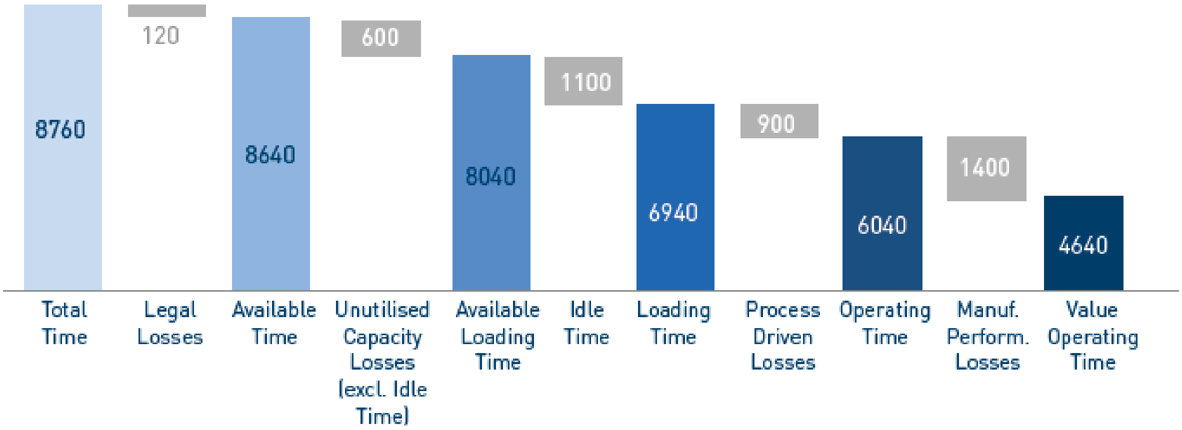


Fig. 4 Numerical example of the time classification

2.4 Overall Equipment Efficiency (OEE)

Overall Equipment Effectiveness (OEE) measures the operational performance of the production line taking into account Manufacturing Performance losses and Process Driven losses. It reflects how effectively the Loading Time is being used to produce Good Volume.

As a minimum, the OEE measure should be calculated for every Production Order. It is also recommended not to ignore the value of this measure in the management routine of the factory (per shift/day/week etc). The standard method of calculating OEE considers the actual Good Volume at the end of Line, as it was confirmed at the end of the Production Order, along with the required Loading Time:

$$Overall\ Equipment\ Effectiveness\ (OEE) = \frac{Value\ Operating\ Time}{Loading\ Time}$$

In order to improve OEE, we need to measure Manufacturing Performance losses and Process Driven losses during the Production Order. This is done using either a manual or automatic loss measuring system, depending on the capability of a given Factory.

The recording of Manufacturing Performance losses and Process Driven losses by the loss-measuring system should be made at the Bottleneck machine

In order to keep track of the different losses and to manage them properly, two additional measures have been introduced in addition to OEE. These will help to segregate responsibility and add more granularity for OEE improvement.

The first one is the Manufacturing Performance (MP): this is a measure of Manufacturing Performance Losses and is the sole responsibility of the Manufacturing department since most of the losses are under their control.

$$Manufacturing\ Performance\ (MP) = \frac{Value\ Operating\ Time}{Operating\ Time}$$

The second one is the Shared Performance (SP): this is a measure of Process

Driven losses, and is shared among Manufacturing, Planning, Maintenance, Technology Innovation, etc.

$$Shared\ Performance\ (SP) = \frac{Operating\ Time}{Loading\ Time}$$

In theory, a calculation of OEE can be made by multiplying MP and SP together.

$$OEE = MP\ \times SP = \frac{VOT}{OT} \times \frac{OT}{LT} = \frac{VOT}{LT}$$

Ideally, the OEE obtained using the formula above and that calculated when the procedure showed before is applied, should be the same. If not, then this is because of unaccounted (or inaccurate assessment of) losses in the loss-measuring system.

2.5 Output Reliability (OR)

Output Reliability (OR) measures the reliability of a Factory to deliver an agreed Production Plan, which has to be frozen from the first production confirmation of a pallet or unit to a production or process order. This allows for the Factory to be matched to a responsive, demand-driven supply chain where there is a requirement to be flexible to customer demand.

Where a production or process order is greater than 24 hours, then adjustments of the order header quantities will be accepted. In no circumstances should the production or process order quantity be adjusted after the order to match the production run quantity. The customer order quantity must remain to identify the OR.

The measure is produced on a daily basis and consolidated to monthly OR as volume weighted average across days.

$$OR = \frac{\sum Final\ Product\ (plan - ABS\ (actual - plan))}{\sum Final\ product\ plan} \times 100$$

Any product rejected for quality or hygiene incidents should not be recorded as production output in this measure.

Any production in ‘excess’ or ‘missing’ against the original plan should penalise the KPI equally. Hence the data is computed in absolute figures.

3. Manufacturing process

The chapters third and fourth are the core of this paper, containing the objective of this thesis, highlighting the criticalities that have found during the work analysis and which improvements actions have been taken. In the following paragraphs the current status of the production plant will be presented.

3.1 Plant layout

As previously said, the production process is centralized in only one plant. This ensures the company to keep a high-quality control on the product, such that the product purchased and consumed in a store is exactly the same of a store on the other side of the world.

Layout of the plant is organized as follows:

- Ground floor dedicated entirely for the production and packaging of confectionary products;
- In 1st and 2nd floors are located all the offices (Maintenance, HR, IT, Finance, Procurement, Production, R&D, Quality Control).

Besides, the ground floor is subdivided in 4 departments organized in such a way to follow the production flow and they are named according to the different production which takes place in there:

-Bakery

-Fruit transformation

-Liquid mix and bags

-Packaging

The realization of the ice-creams and ice-sticks takes place in the liquid mix department, where all the ingredients are stirred and then moved to the bags area or to the packaging department. If the product is a fruit-based flavour, the preparation starts in the fruit department, where the fruit is processed to become purees and juices. It is firstly washed in two pools and then, according to the type, it can be peeled and grinded or squeezed, like for lemons, and lastly added to the liquid mix.

The bakery department, instead, is used for the manufacturing of the biscuits. The raw materials are transformed into dough, which is cut in different shapes, according to the typology, and cooked in the oven. This last department has a completely separate process flow, which encounters the one of ice creams only

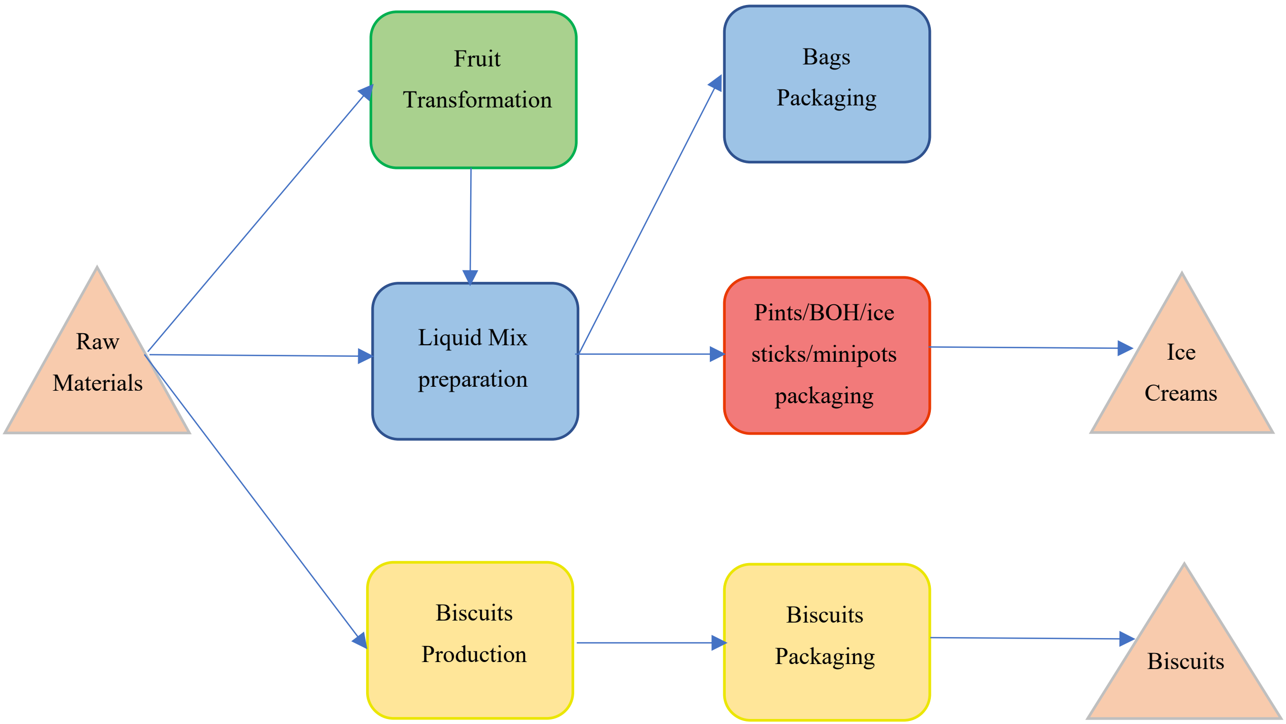


Fig. 5 Scheme about the process flows in the production site and of how the departments are linked among them. Each department is characterized by a different colour: Green for fruit transformation, Blue for liquid mix, Red is for the packaging one and Yellow for the bakery.

in the moment in which the meliga biscuits are produced: these last are one of the key ingredients in the flavour named “Crema di GROM”.

The way the departments are linked and the process flows are showed in Fig. 5 , where the departments are indicated with different colours (the same used in the plant) and the warehouses have a triangle shape.

3.2 Boundaries of the study

During the internship, due to the pandemic which forced the company to keep temporarily close several shops, the workforce was mostly focused on the packaged ice cream production line. Since the end-of-line is the same for both the ice-sticks and pints, they cannot be produced simultaneously. Therefore, the bakery department and bags and ice sticks realization will be ignored in this paper. Moreover, the production of pints has several criticalities and the most crucial operations among those carried out in the factory. The work analysis of the line was facilitated due to the fact that it works as a continuous processing, which allowed a very detailed and complete analysis on the key performance indicators.

3.3 Packaged ice cream production cycle

The production of the confectionary products can be considered as Make to Order (MTO) process, that is, the quantity and types of products to manufacture depends on the orders received by the customers.

The number of products to manufacture is identified by the production planner through a bargaining activity with the virtual factory, located in Poland, according to the flavours and formats requested by the different countries.

Starting from this information, the planner realizes a production schedule called MPS, Master Production Schedule. This plan takes into account the seasonality of the ingredients, the availability of raw materials on stock and the production capability of the line. For this reason, the MPS is finalized in collaboration with the production manager, who has a deep knowledge of the production modalities and timings required by the line to satisfy the company needs.

After the MPS is approved, procurement department is activated to ensure the movement of the materials needed in the right place and at the right time both for the realization of ice creams and for packaging. Placing orders is a crucial phase since some raw materials have a short expiration date and have to be made available and used in few days.

Once all the materials are made available, the preparation of liquid mix begins and when finished, the mixture is transferred to the tanks in the packaging department. Meanwhile, some initial operations are carried out: line operators supply the hoppers with jars and caps; besides, the quality controllers check if the mixture has reached the right percentage of embedded air in the ice cream (this percentage is named overrun).

When these operations are complete and the ice cream reaches the correct texture, it is pushed through the pipes up to the filler. Since the pipes are initially warm, the ice cream starts melting and it cannot be put inside the jars as far as it reaches a creamy texture. In some cases, this waste can be collected and re-use in future production of the same flavour.

For some products, it is necessary to add inclusions like grains or biscuits, which are incorporated in the ice cream before putting it in the tubs. For this addition, a line operator inserts the inclusions inside the hopper of a machine called Fruit Feeder; during the production, the mixture flows in the fruit feeder and a fixed quantity of the inclusion is added constantly, according to what is required by the product.

After the jars are filled, some conveyor belts bring them in few minutes to the cap-driver, which screws the caps, and the labeller, which applies seal on top of the jar and a label on the lateral surface of it, containing information about the ingredients, expiration date and the batch-code. During the realization of a product, whilst the jars and caps are kept the same, the labels and the seals are changed according to the country of destination and the flavour. Since these elements are changed manually by the operators and the operation can takes few minutes, or for any possible issue that can affect the line, there are buffers: the first after the filling machine and the other one next to the labeller machine.

Afterwards, in order to bring the ice cream to the correct temperature, the product enters in a freezer and remains in there for a time around 50-60 minutes and finally is ready to be packed.

Before the packaging, in the end-on-line, some quality controls are located: a Metal Detector, an X-Ray and a scale. In this phase, the product is checked for its weight and for its consistency which have to fall inside the standard limits specified by the quality department, otherwise they are rejected. Besides, the metal detector controls if any abnormal substance is present inside the jar and, in that case, it is discharged.

Finally, the packaging is carried out manually by the end-of-line operators which accommodate the jars in carton boxes and check visually if any other issue is present: the seal must be properly glued to the cap and the label correctly aligned. The filled boxes are closed with scotch tape and moved to a robot that palletize them and, once filmed, they are moved to the refrigerating room ready to be delivered to the customer. The entire process is summarized in Fig.6.

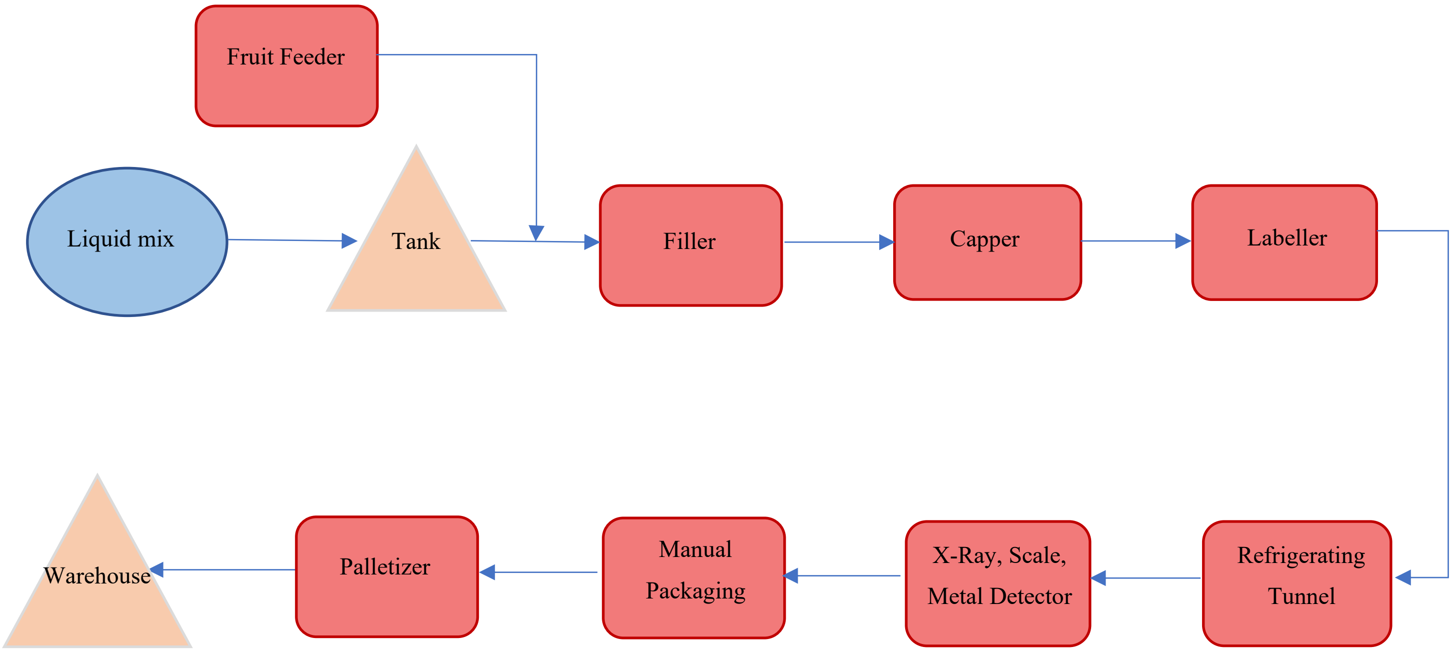


Fig. 6 Representation of packaged ice-cream production cycle, from the liquid-mix to the warehouse

3.4 Data collection

During the production, a certain number of line operators have the additional responsibility to report on the production sheets the information required, which are mainly technical information and then also significant data for the computation of performance indexes and the quantity produced.

The different are three and all data are reported by hand by the operators.

The first one (Fig.7) is related to the liquid mix department where the operator in charge to prepare the mixture has to complete this form. The first section contains the referral code indicating the date, the flavour and the product format. In the second section, the PLC (Programmable Logic Controller) of the machine that makes the ice-cream prints which ingredients and the related quantity needed that the operator has to add to the mixture. The second section is also constituted by the information about the starting and finish time of production, the destination tank of the mix and the actual weight of product obtained written by the operator.

DATE… BATCH… CODE…

	BATCH	%
Ingredient 1	800	53,33%
Ingredient 2	150	10%
Ingredient 3	300	20%
Ingredient 4	200	13,33%
Ingredient 5	50	3,33%
Tot	1500	100%

Starting time automatic ingredients	Finishing time automatic ingredients	Starting time manual ingredients	Finishing time manual ingredients
	Expected weight	Actual weight	Destination tank

Fig. 7 Layout of the production sheet where info about the liquid mix preparation are collected

The second production sheet is a A3 paper filled by the end-of-line operators. They are required to report the starting and finishing time of the packaging process and of the rinse of the line. They also have to indicate the weight of the mixture in the destination tank, in order to check if any waste during the transfer occurred and the quantity of inclusions necessary to be put in the fruit feeder. Finally, it also includes data about the number of pallets realized with the relative numbers of carton boxes, labels, jars and caps consumed for the packaging process. This piece of information is important to keep track of the materials unused for updating the availability in the inventory and for estimating the wastes of materials in the next processes.

The last production sheet (Fig.8) is filled by end-of-line operators as well. They have to report all the rejected products and the reasons of the rejection such as the incorrect application of the seal, the missing of the cap, the melting and so on. This last one is useful to have a reminder of all the wastes with the relative causes and to figure out which format or flavour has a high incident on the waste.

DATE…… BATCH…… CODE……

Poor Filling	*Quality check*	*Temperature detection*	*Melted*	*Absent cap*	*Metal detector*	*End of production*	*Other reasons*

Country label here…

Fig. 8 Production sheet in which the number or rejected units are reported according to the cause

To conclude, all these information are collected by an employee who does not contribute to the production process and is in charge of transfer all the data into the system and into an Excel file created for the performance analysis, the computation of time waste and for an economic evaluation.

3.5 Criticalities

In order to improve the quality of the performance analysis and the Excel program itself, it was important to find the criticalities that affected the process.

First of all, the information collected on the production sheets are reported manually and this can imply some unintentional errors like inserting an inaccurate value or missing it. Moreover, this error's probability is amplified from the fact that a person who is not involved in the production line has the role to report these data in the system, even several days later.

The amount of information collected is very high due to its technical relevance and to the complexity of the process; however, a decent percentage of these data could be used in a more efficient manner and others could be neglected in order to carry out a production performance analysis.

One of the best options to make it effective and more efficient was to re-think the production sheets' layout and content, but it was not doable during the internship. The reason is that the time spent in GROM was less than ten weeks and a significant change as the one mentioned above would have taken too long to be implemented, especially considering the time needed to inform and train the operators to correctly fill the new forms.

The efforts in collecting data in the Excel file are mainly focused to track the products manufactured and material used (helpful for procurement, planning departments and accounting). Thus, a proper performance analysis on long term - which would be necessary following the WCM guidelines to identify the most critical operations and search for improvement procedures - is not performed.

From a technical and practical point of view, the program's comprehension is generally difficult due to the high amount of data collected. Moreover, editing the formulas requires a deep knowledge of Excel, since the file is completely implemented through macros written with the programming language *Visual Basic* (that is explained in next chapter). The data registration and losses computation are performed by a macro, which takes a bit of time to handle the data; as the file contains even the data about the past years, it is uselessly large and so affects the time required by the system.

Remembering these concepts, a methodology was carried out with the purpose of making a simplified version of the program aiming only at the production analysis. At first, only the relevant data were kept. They were used to estimate the OEE and OR according to the guidelines of the MPP Code. Later on, a new page on the file was added with the objective to have a complete and clear view of the wastes along the entire process.

To fulfil the company needs, all the relevant values coming from the system were reported in an interactive dashboard programmed using Microsoft Power BI, since it allows to display the output in a more visual and dynamic way.

4. Implementation

In this chapter, the editing and the building up of more accurate tools for the performance evaluation of the production line will be explained with explanatory images attached.

To simplify the data reported in the Excel file, the first step was to determine which information were more relevant, aiming to perform the analysis of the sole production. To do so, with the help of the Production Manager, all the information related to the procurement and planning departments were deleted and some changes have been made in the program. Fig. 9 shows a comparison between the user interface of the previous version of the file and the final one, in order to visualize the main changes. In the former, the operator was in charge of inserting all the number of pallets realized and their referral code in relation to the destination countries, picking them from the production sheets. Indeed, in order to differentiate the batches produced, each combination of format, flavour and destination country is identified by a unique code named MDRD.

Since this operation is merely aimed to track the quantity of orders received by the different nations, this information is not inherent with the analysis which should be performed. Then this piece of information was deleted adding the possibility to just sum up the number of total pallets manufactured. Through the selection of the typology of product, the system automatically inserts the number of pieces per pallets, facilitating the compilation and computing the total number of products manufactured as

$$number\ of\ pallets\ manufactured\ \times\ products/pallet.$$

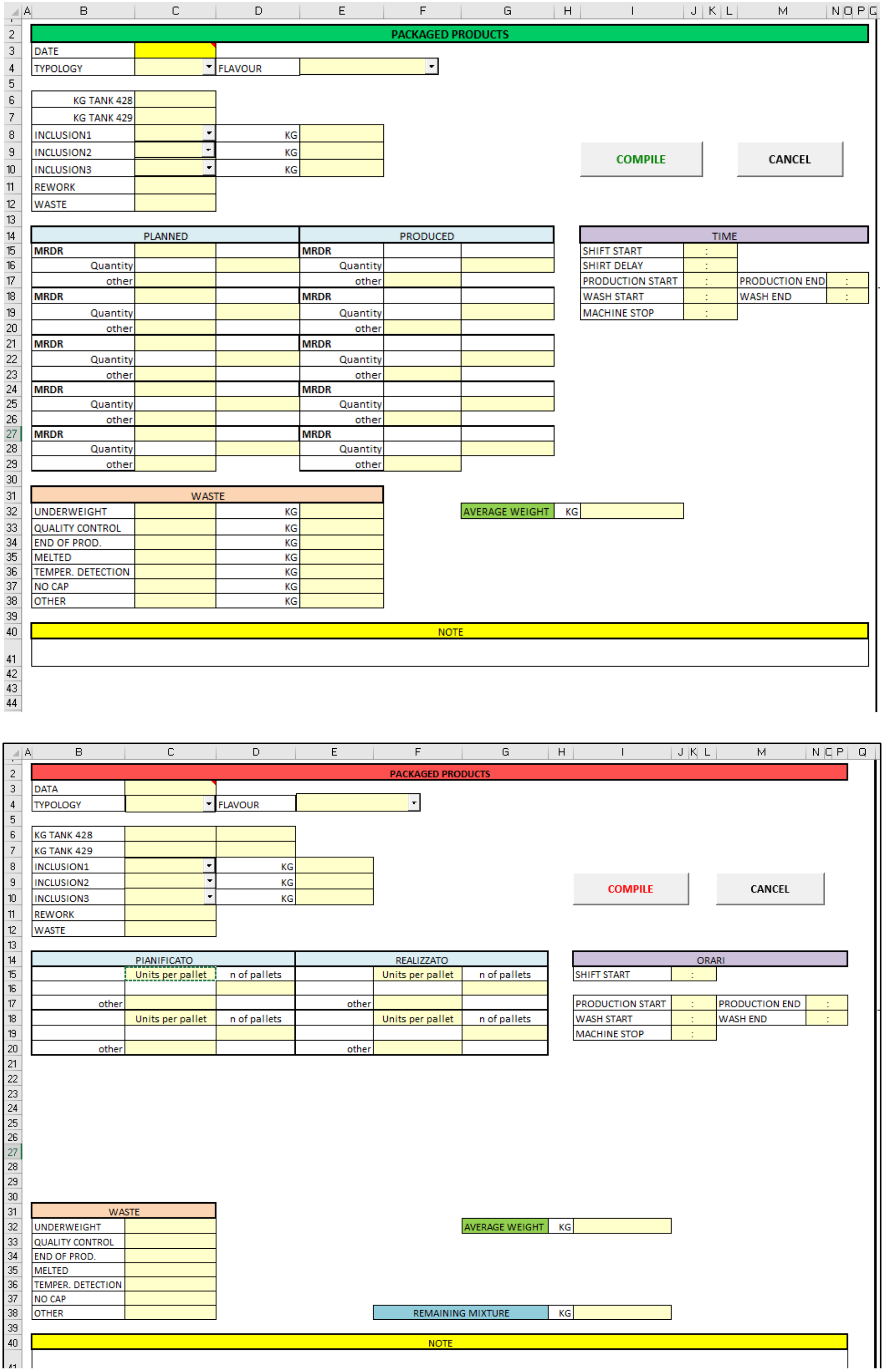


Fig. 9 Comparison of the "insertion" page of the system before and after all the changes made. The image above refers to the previous version, while the other below is the latest one.

Regarding the section below of the same page, it contains the information reported on the third production sheet. As it is possible to notice, the table was modified eliminating the second column where the weight of the different wastes was required. That's because previously this production sheet had a different layout and also contained those data; since nowadays it is not like that anymore, the total weight of wastes is computed using the average weight of the products.

This value is made available thanks to the scale located in the end-of-line, which measures the weight of each single product and when the production ends, in the PLC of the machine these data are recorded and then recovered by the quality department.

As last change, a new data was introduced called "Remaining mixture". Since unforeseen issues or production slowdown could occur, not all the prepared liquid mix is packaged within the same day. For this reason, it has not to be considered as part of production of this day, indeed this quantity is used in the production of the following day.

Once all these changes were made about the entering of the data, then the work was aimed in the writing of a code in order to compute the KPIs, OEE and OR.

4.1 Visual Basic

One of the more required solutions to elaborate, analyse and present data is Microsoft Excel. Using the spreadsheets of Excel, which are a key component of the Microsoft Suite, it was allowed to the users to create graphical representations of sales and profits, business calendars and reports.

If it is used regularly in order to insert data, as database, or as an application for spreadsheets, it is possible to avoid making the same operations over time and repeat complex sequences. To this aim, in the software there is a programming environment where it is possible to write codes using the Visual Basic (VBA) language. Visual Basic was designed to be a complete programming language that contained ordinary features, such as string processing and computation. The visual environment is characterized by a drag-and-drop feature which allows programmers to build a user interface that is easy to use. Programming is a combination of visually arranging components or controls on a form, specifying attributes and actions for those components, and writing additional lines of code for more functionality. It significantly increases the general features and what is possible to do in the entire Office package. In a program where is usually used only the standard functions, it is made available a space where complex algorithms can be implemented, enhancing the flexibility to perform multiple tasks and more important it allows to automate customized functions frequently used.

4.2 OEE and OR

As already described in chapter 2, the OEE is computed as

$$OEE = Value\ Operating\ Time\ /\ Operating\ Time$$

Where the Value Operating Time is: $VOT = \frac{Good\ Volume}{Nominal\ Speed}$

The Good Volume indicates the quantity produced compliant with the quality standards of the company, so it is not equal to the factory volume. About the Nominal Speed it is defined in the MMP Code of Unilever as "the highest sustainably achievable speed at which a given product can be manufactured on a given line at perfect efficiency and with no losses, safeguarding all Quality and Safety standards and attainable for the corresponding Lot Size".

The nominal speed (NS) of the entire line is equal to the one of the bottleneck. Since the speed of all the machines was regulated in a way that they are the same of the bottleneck's one, to determine the numerical value the filler was used as reference. The actual speed of the machine is measured as strokes per minute. The use of this unit of measure presents a drawback, that is the significant difference in the speed according to the typology and flavour to produce.

For this reason, in order to have a unique value to use in the formula that is as accurate as possible, the nominal speed was computed using the values of a single typology for the different flavours and weighted on the total good volume produced of the previous year.

$$Nominal\ Speed_{pint} = \frac{NS_A \times Good\ Volume_A + NS_B \times Good\ Volume_B + NS_C \times Good\ Volume_C + \cdots}{Tot\ Good\ Volume_{pint}}$$

In the example above, the nominal speed of the line during the production of the pints, was computed as the sum of the nominal speed for the generic flavour *i-th* times the good volume of that flavour, divided by the total good volume of the pints.

After the computation of the VOT, the Operating time is instead computed starting from the Loading Time and then subtracting the Process Driven Losses. The operating time is calculated over two shifts of 8 hours each one.

All those stops and losses done on purpose allowing to complete certain activities related to the normal operation of the line are classified as Process Driven Losses and are differentiated in the following causes:

- Preparatory & Close out time: it is the time required by the line to be ready to operate, in which the operators set up all the machines and prepare the materials needed for the packaging and the amount of time to close the line and to start the washing phase at the end of the daily production
- Change over & Product Change: this cause is related to all those time losses due to a format change that requires a long time to be completed (even more than 5 hours in particular cases) since the filler, the capper and the labeller must be re-set in order to operate correctly. In this category even the seal or the label changes fall. At the end of a label reel, the operators have to remove the lock which prevents to the reel of moving during the production process, remove the finished reel and load the new one on the machine. After that, the lock will be placed again on the reel and the operators will restore the production process. In the case of the same flavour but different destination, the frontline leaders will have to substitute not only the label but also the seal. The operation performed will be the same of the one described for the labels, but it is done in a different part of the machine. These last ones are considered as minor losses and are not reported because of their negligible values.
- Cleaning & Sanitation: the cleaning and sanitation is a daily operation which takes place at the end of the production, in which not only the machines and pipe system are cleaned but also the entire work environment. In addition, whenever in the same day two or more different flavours are processed, it is really important to clean thoroughly the entire line due to the presents of allergens, which could contaminate the products of the

following production. For this reason, this process is highly variable and depends on the type of allergens inside the liquid mix of the current and following production (it can vary in a range between 15 and 100 minutes)

- Meal Break: this kind of time losses is not accounted in this site because the operators have their meal break one at time, without stopping or compromising the work
- Maintenance: this last one which is a programmed maintenance is scheduled such that it takes place only when the line production is not working, avoiding interruptions.

Another type of time losses affects the OEE value and this one, on the contrary of the process driven losses, occurred unexpectedly stopping the line when it is intended to be in production and is named Manufacturing Performance Losses. Some of the most frequent machine downtimes which occurred during the internship concerned about the following machines:

- Tunnel: this machine has the higher rate of problems and represents a criticality because of the impact it may have on the products. Sometimes it happened that suddenly the conveyor belt which transports the units get stuck and this leads to a stoppage of the fans. If the tunnel stops working for a significant amount of time, this may impact on the production due an incorrect freezing of the jars and then severely affect their quality.
- Labeller: in some cases, due to errors in the application of the labels or in reading the code applied on the labels, this machine induced a production slowdown since the maintainer had to stop the line.
- Palletizing robot: more than once, some of the sensors installed on the robotic arm stopped working and this created relevant issues to the production. One of end-of-line operators was forced to put manually all the boxes on the pallets significantly reducing the time of production.

After all these information have been collected on the production sheets and inserted on the Excel file, it was possible to create a macro to compute the OEE indicator (the result is shown in Fig. 10).

A	B	C	D	E	F	G	H	I	J	K	L	M
TYPOLOGY	Loading time	VOT	Preparatory & close out time	Changeover & Product change	Cleaning & Sanitation	Process Driven Losses	OT	Manufacturing performance losses	**OEE**	**MP**	**SP**	**OR**
PINTS	960	636,44	02:00:00	00:00:00	00:30:00	02:30:00	810	173,6	66,30%	78,57%	84,38%	88,40%
PINTS	960	674,00	01:00:00	00:00:00	01:40:00	02:40:00	800	126,0	70,21%	84,25%	83,33%	84,25%
PINTS	960	560,00	04:00:00	00:30:00	00:50:00	05:20:00	640	80,0	58,33%	87,50%	66,67%	98,02%
PINTS	960	725,56	03:00:00	00:00:00	00:30:00	03:30:00	750	24,4	75,58%	96,74%	78,13%	100,00%
PINTS	960	679,56	03:00:00	00:00:00	01:00:00	04:00:00	720	40,4	70,79%	94,38%	75,00%	99,93%
PINTS	960	658,00	02:20:00	00:15:00	00:40:00	03:15:00	765	107,0	68,54%	86,01%	79,69%	93,53%
PINTS	960	605,11	04:50:00	00:00:00	00:38:00	05:28:00	632	26,9	63,03%	95,75%	65,83%	99,15%
PINTS	960	760,00	01:30:00	00:00:00	00:35:00	02:05:00	835	75,0	79,17%	91,02%	86,98%	100,00%
PINTS	960	555,56	02:40:00	01:00:00	00:50:00	04:30:00	690	134,4	57,87%	80,52%	71,88%	81,70%
PINTS	960	720,00	01:35:00	00:00:00	01:10:00	02:45:00	795	75,0	75,00%	90,57%	82,81%	100,00%
PINTS	960	630,22	03:25:00	00:00:00	01:19:00	04:44:00	676	45,8	65,65%	93,23%	70,42%	92,60%
PINTS	960	548,22	01:15:00	00:00:00	01:10:00	02:25:00	815	266,8	57,11%	67,27%	84,90%	90,37%
PINTS	960	760,00	01:45:00	00:00:00	01:10:00	02:55:00	785	25,0	79,17%	96,82%	81,77%	100,00%
PINTS	960	645,78	02:30:00	00:00:00	01:00:00	03:30:00	750	104,2	67,27%	86,10%	78,13%	99,86%

Fig. 10 Table which shows the OEE computed for some production days in March. It contains information about the losses differentiated as Manufacturing Performance Losses and Process Driven Losses

From a quick analysis of the OEE results on March it is possible to notice that a high percentage of the values are over the target OEE set to 60%, even though there is a non-negligible gap between the lowest and highest values (57,11% and 79,17%). With the aim to investigate a bit more about these results other two indexes were computed: MP and SP, already described in chapter 2.

The former refers to those losses identified as Manufacturing Performance Losses and the latter instead refers to the Process Driven Losses, in order to better understand which most affects the performance.

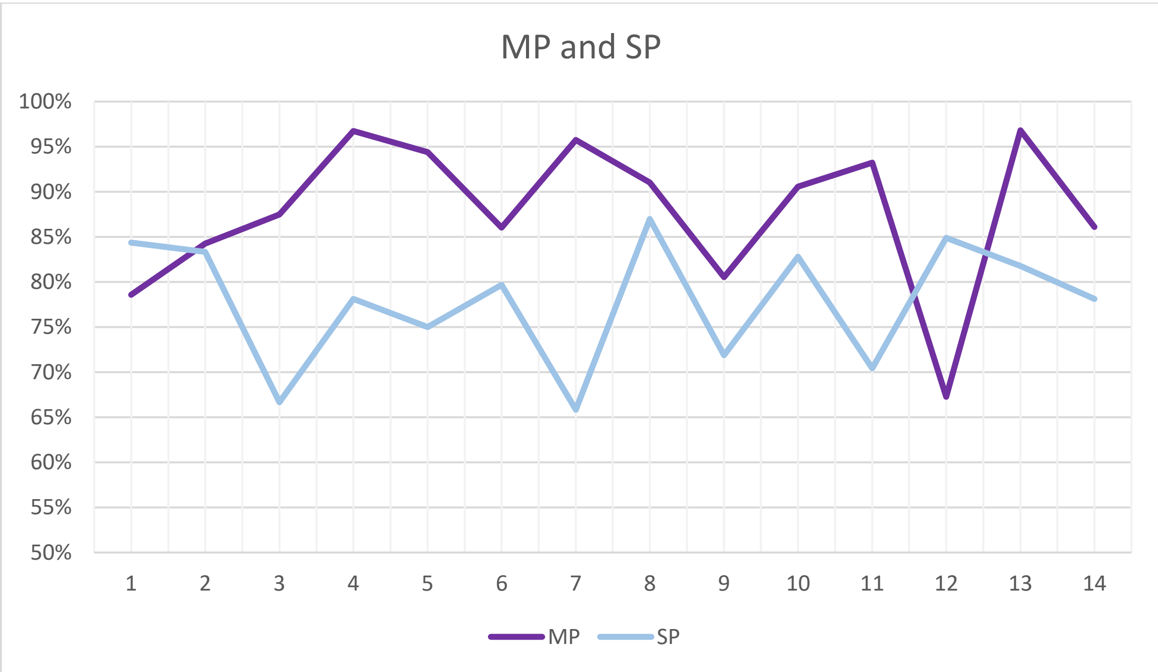


Fig. 11 The line diagram shows that over a sample of 14 days, the MP is almost always over the SP. It demonstrates that OEE is mostly affected by the Process Driven Losses

Looking at the graph in Fig.11, it is easy to notice that the MP curve is always above the SP one. It means that the SP values have a higher impact on OEE and consequently main causes of a low OEE are related to the Process Driven Losses. Knowing this, the efforts of the managers should be focused to operate on the losses which negatively reduce the production time and rate.

To conclude, the other relevant KPI computed in the same file is the OR, which measures the ability of a factory to match an agreed production plan and the realized one.

Computed as $$OR = \frac{Planned\ Volume - |Good\ Volume - Planned\ Volume|}{Planned\ Volume}$$

Planned volume is equal to the total products manufactured which is higher than the Good Volume as a consequence of the quality defects.

All these values are computed on a daily basis but to have a clear view of the performance and to compare on a long-time basis, the results are summarized in a table according to the month or the typology of product as shown in Fig.12

Month	Typology	Compliant units	MONTHLY OR	YTD OR
gennaio	pints	310990	93,31%	93,31%
	minipot	0		
	ice-sticks	5160		
	BOH	0		
febbraio	PINTE	152611	98,08%	95,84%
	MINIPOT	134880		
	GHIACCIOLI	58140		
	BOH	27798		
marzo	PINTE	493981	97,17%	96,40%
	MINIPOT	0		
	GHIACCIOLI	17620		
	BOH	0		
aprile	PINTE	105656	85,11%	94,82%
	MINIPOT	55536		
	GHIACCIOLI	8760		
	BOH	3572		
maggio	PINTE	0		94,82%
	MINIPOT	0		
	GHIACCIOLI	0		
	BOH	0		
giugno	PINTE	0		94,82%
	MINIPOT	0		
	GHIACCIOLI	0		
	BOH	0		
luglio	PINTE	0		94,82%
	MINIPOT	0		
	GHIACCIOLI	0		

Fig. 12 Table contains the total OR for a single month and the Year-to-Date values

The OR which has a Year-to-Date value close to 95% means that the factory has a good response to the customer requests, even if changes in the production plan during the week often happen.

4.3 Waste Clustering

During the manufacturing and the transformation of a product, several activities generate wastes (considered to be permanent, because they are related to the process itself). Some other types of wastes instead are for reasons of non-alignment with the quality standards or production errors (called occasional wastes).

Referring to the packaged production line of GROM, there are four main kinds of wastes, whose location along the process is illustrated in Fig.13.

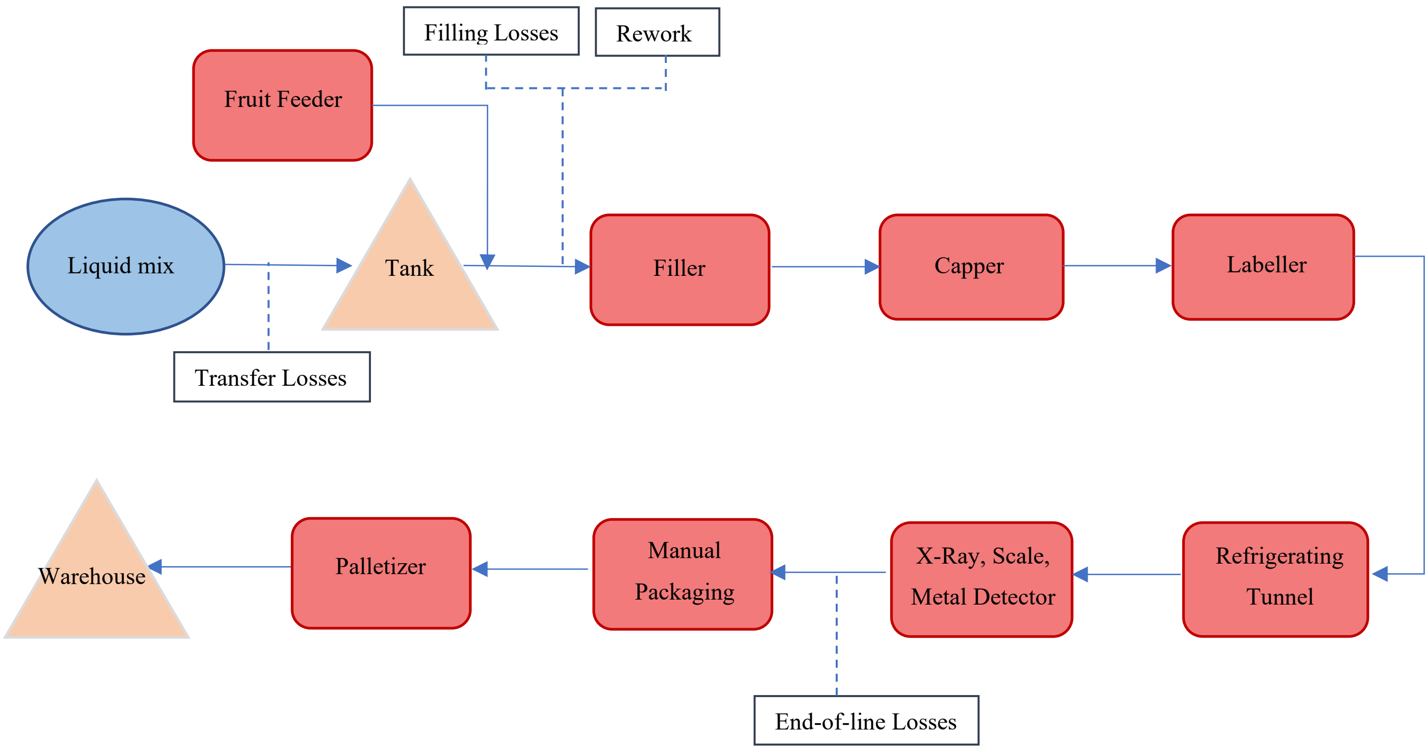


Fig. 13 The location of the production losses along the process

1. Transfer Losses: during the transfer from the liquid mix department to the tank in the packaged line there are some losses linked to the process. Indeed, when the ice-cream flows through the pipes it has to push the residual water used as cleaning liquid and this causes a mixing of the two. Therefore, the very first part of the mixture is discarded until the material is enough good to be processed
2. Rework: this named is due to the fact that the losses occurred during a production can be re-used for the following production of the same flavour. Even though this sounds to not be a waste, it actually entails during the current production the consumption of resources and time of the operators. In the initial phase of the production, the liquid mix passes through the refrigerator to be frozen and to incorporate air. Until the mixture does not reach the right overrun percentage and texture, the liquid mix is collected. Another moment when rework is produced is the starting phase of the filling process when the ice-cream reaches the filler flowing into the pipes. Since these at the beginning are warm, the mixture starts melting and it cannot be put into the jars
3. Filling Losses: these losses concern with those flavour which presents inclusions in there. During the collection of rework in the initial stage, the product is not ready to be filled in the jars but in this case it cannot be collected as for the rework due to the presence of inclusions: they can alter the chemical properties of the mixture and constitute a real loss.
4. End-of-line Losses: at the end of the production, thanks to the metal detector and the scale, many jars could be rejected for several reasons. Those are:
   - Underweight. For all the typology of ice-cream is set a lower limit of weight that a jar should reach otherwise it is rejected

- Quality control and temperature detection represent the fixed numbers of jars that are taking by the quality department during the production to check the product and its chemical properties
- Melted pints which have a density which is under the limit imposed by the standards and is detected by the X-ray machine
- Misapplication of label or lid. In some cases, due to the temporary malfunctions of the capper or the labeller, these jars have no lids or a wrong application of the label so they must be refuted.

Knowing this info, on the same Excel file another page was created to every type of losses are reported and clustering, underlying which one has an more impact on the total losses of the production process.

Starting from the actual mixture produced in the mix department, the transfer losses are computed as the difference between this last value and the total mixture that reached the tank in the packaged department. If inclusions are required in the ice-cream, then the amount of inclusions are added to the total weight and subtracted the initial losses (rework and filling). Once the process ends, the system compute automatically the weight of the end-of-line losses as number of jars rejected times the average weight. The total waste in a production is computed as follow:

$$\frac{end - of - line\ losses + filling\ losses + rework + transfer\ losses}{total\ liquid\ mix\ produced + inclusions\ weight}$$

Checking the results shown in Fig.14 of some days of March, it’s possible to notice that the overall values are lower than 1% even if, the most influencing losses are the transfer ones. While rework and filling losses have always a very low impact, the end-of-line losses for some particular cases become a significant problem and thanks to this program it is possible to identify which typology of product or flavour should be revised in the process.

	C	D	K	N	O	Q	S	U
1	MONTH	TYPOLOGY	TRANSFER LOSSES (kg)	REWORK (kg)	FILLING LOSSES (kg)	END-OF-LINE (kg)	TOTAL LOSSES (kg)	TOTAL LOSSES %
58	marzo	PINTE	317	0	0	7,37	324,37	0,078%
59	marzo	PINTE	137	26	0	24,49	161,49	0,642%
60	marzo	PINTE	57	58	0	0,00	57,00	0,000%
61	marzo	PINTE	374	0	60	128,71	562,71	1,934%
62	marzo	PINTE	174	0	0	13,48	187,48	0,151%
63	marzo	PINTE	0	0	0	5,02	5,02	0,062%
64	marzo	PINTE	102	0	0	5,02	107,02	0,122%
65	marzo	PINTE	0	0	0	4,83	4,83	0,239%
66	marzo	PINTE	206	66	0	14,75	220,75	0,234%
67	marzo	PINTE	312	0	0	9,82	321,82	0,088%
68	marzo	PINTE	13	37	0	18,52	31,52	0,923%
69	marzo	PINTE	0	779	20	131,20	151,20	2,098%
70	marzo	PINTE	198	0	120	18,26	336,26	1,206%
71	marzo	PINTE	7	57	0	6,72	13,72	0,278%
72	marzo	PINTE	255	55	0	0,68	255,68	0,010%
73	marzo	PINTE	319	38	0	13,22	332,22	0,156%
74	marzo	PINTE	0	154	60	67,70	127,70	1,442%
75	marzo	PINTE	433	0	0	41,32	474,32	0,406%

Fig. 14 Clustering of the waste and computation of the losses produced during March

To conclude, in order to improve the capability to monitor the production performance and to identify criticalities and weaknesses, a tool in Excel was modified and extended using the programming environment that is in the software. Using these code lines it was possible to create customized functions to compute the KPIs requested by Unilever, starting from the data collected in the production sheets.

Once this document was complete, it is important to make the most interesting results easy to compare and manage. In order to achieve this, another Microsoft software was used which is perfectly suitable for the mentioned goal and it is Power BI.

4.4 Microsoft Power BI

Microsoft Power BI is a collection of software services, apps, and connectors for enterprise-wide data analysis, viewing, and sharing reports. They interact with data from hundreds of supported on-premises and cloud-based sources, to transform unrelated data sources into a set of coherent, visually appealing and interactive information. With Power BI Dashboards, users can get an overview of business data that brings together the most important indicators, updated in real time and available on desktop PCs, smartphones or tablets.

First, Power BI is available in two versions: Power BI Desktop and Power BI Service. Power BI Desktop is a free tool, a "stand alone" application that allows to upload data and perform mashups (relate and reshape data, even from multiple sources), and create reports that can be shared with other colleagues simply by sharing the file.

Power BI Service is the web version that allows to perform most of the operations available in Power BI Desktop, but adds some web sharing features, the consultation of online reports, the automatic updating of data, the ability to ask questions in natural language. For these advantages, this last version was preferred.

It is possible to load data from different sources (Excel, Access, Text, SQL Server, Web), although the Web version is more limited from this point of view.

Once the data are loaded, it permits to manipulate the data creating relationships, adding columns, and performing transformation tasks on the data (remove duplicates, remove errors, add calculated fields). Finally, using the instruments in the software is possible to create customized graphs or diagrams in order to display the values of interest in the best way.

With the purpose to make usable the data inside Power BI, some changes were needed in the Excel file. Firstly, all the information collected were organized using the table Excel feature: this tool allows to connect the information inside the page, to register the column names and create structural references among them.

All the data in Excel are simply information collected and with no relation among them. Power BI allows to import those data and create a real database where the tables are linked using a unique key transforming the data in related and interactive information (example of some keys are Date, Flavour and Typology). The model created is shown in the Fig. 15 below.

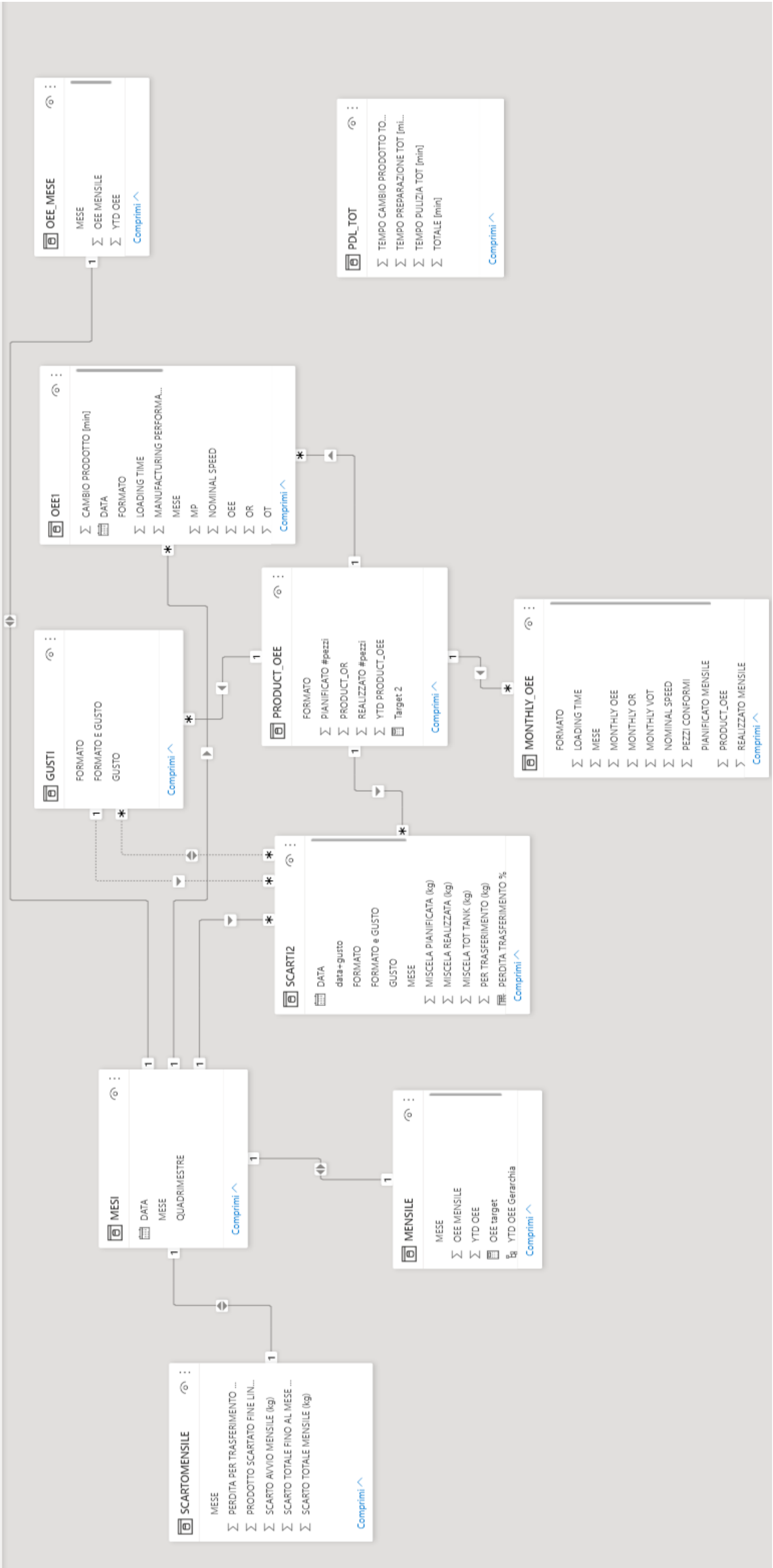


Fig. 15 Relationship model which connects the different tables in order to make coherent and related reports

Thanks to the wide library of Power BI, two reports have been created one related to the productivity and one to the waste. Among the tools available, some of those are more interactive and catch the attention of observers such as the one used in the second report.

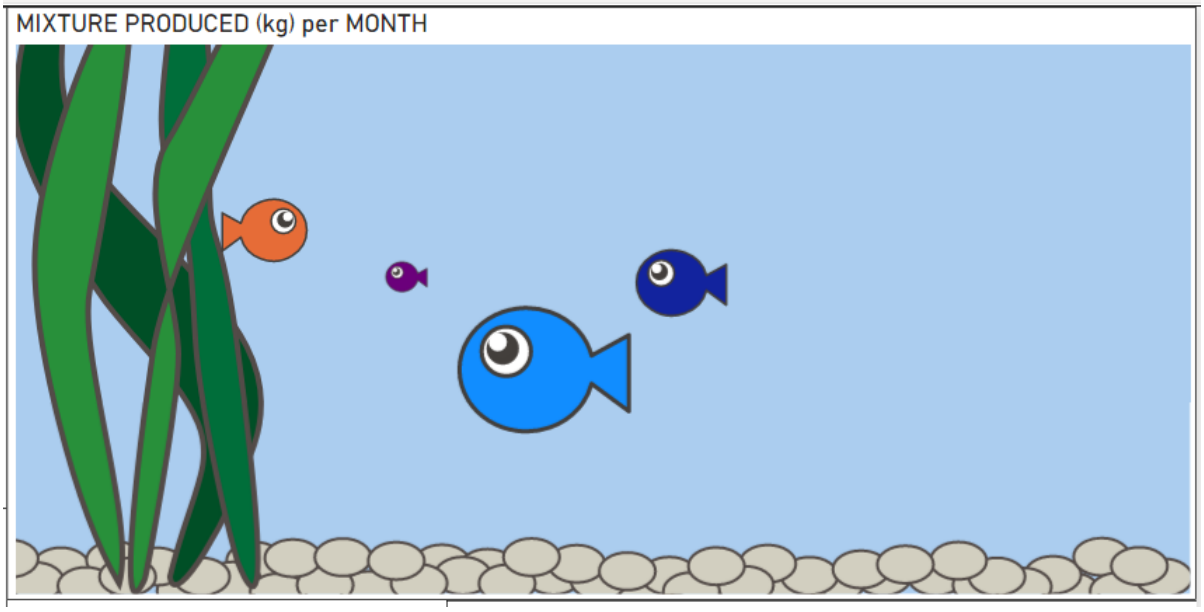


Fig. 16 Visualization of data through an interactive aquarium

The aquarium in Fig. 16 is just a simple graph where the number of information contained is equal to the number of fishes and the values are proportioned to the size. This could be useful also to involve more people in being interested to analysis and reports.

One of the main advantages in using this dashboard is the possibility to filter the information in an interactive way: clicking on a particular day, format or flavour, only the information related to that particular specification are shown. This feature helps in investigating the sources of issues, focusing on those operations and productions where improvement actions should be taken. The usage of Power BI Service was preferred to the Desktop version because of the possibility to systematically refresh the values imported by Excel, which changes every time the operator upload the new production records on it.

Therefore, the file created was inserted into the informatic system of the company such that it can be visualized but not edited by those the author gives the permission to.

4.5 Limitations

Some of the main criticalities of the performance evaluation system were faced and solved by some limitations keep standing. First of all, the Excel file is a quite complex due to the great number of line codes written in VBA and moreover, different people worked individually on that file, implementing modifications by their own. This means that only one of the programmers (or an expert) is capable to make modifications to the file. This is a relevant restriction.

Another limitation is the manual collection of data from the production process. This leads inevitably to some human errors and these are doubled even during the transferring phase of those data into the software.

Finally, in order to reduce the amount of information in the single Excel file, just the current year are kept, deleting the ones referred to the last year. Nevertheless, the comparison of results between adjacent years is more complicated.

5 Conclusions

The work performed during the internship was divided in different steps. The first one consisted into studying which kind of information were required to compute the KPIs, as described into the guidelines of Unilever. Most of these information come from the production sheets filled during the production and they are reported on an internal local Excel file where a performance evaluation is conducted. Using these data, several macros have been written using Visual Basic to facilitate the insertion of data in the file and to compute the OEE and OR. The importance of monitoring the performance is huge and it allows to accurately identify the criticalities and the main problems in order to take improvement actions. A similar analysis was carried out focusing on the volume of wastes produced during the process, clustering and quantifying them according to the typology.

To link all these values which could appear unrelated, an interactive dashboard was created through Microsoft Power BI. It also displays the indicators and graphs in a more direct way and allows to filter the data across different tables. These new tools represent good means for the managers in finding production problems and to share process performance with the employees or the directors.

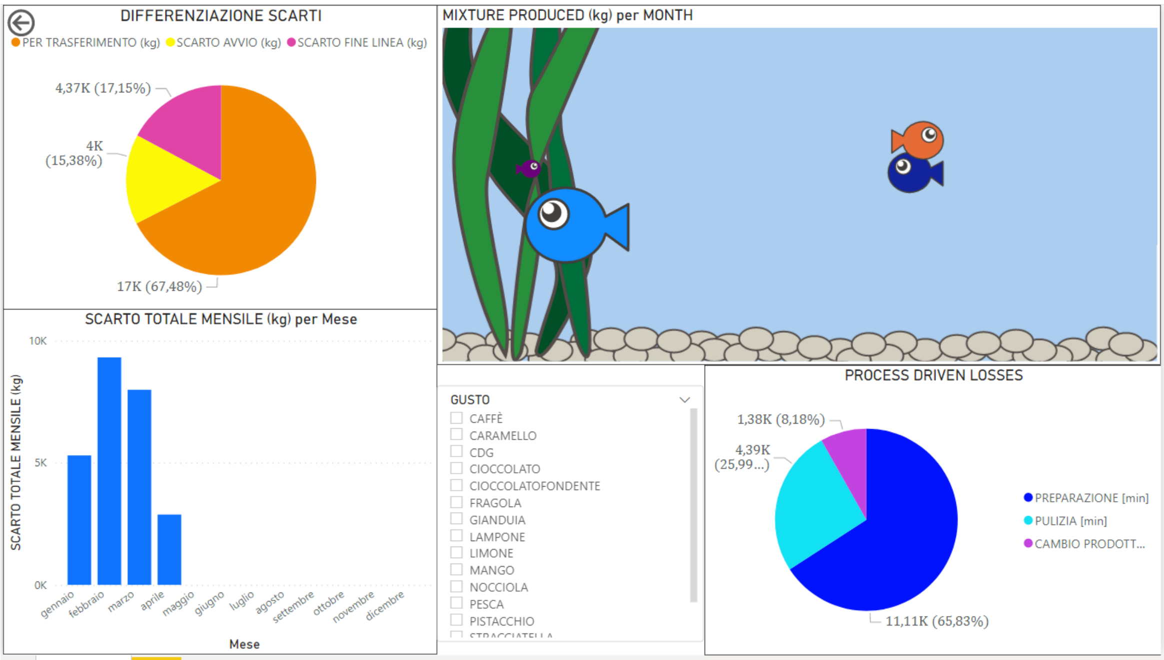
Unfortunately, due to the short time spent in GROM, there was no possibility to make a concrete analysis of the KPIs computed using the macros since there were not enough observations to carry out a deep study. Therefore, a more exhaustive evaluation could be made in the future with a high number of values.

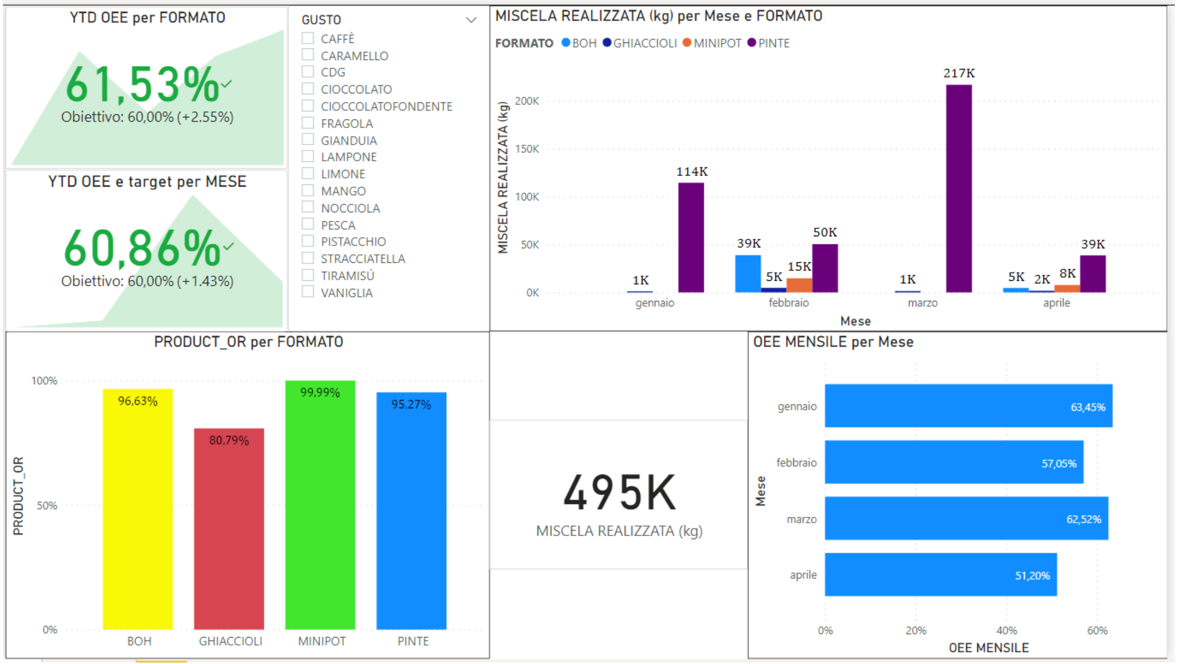
5.1 Future improvements

Although the work performed, several actions could be taken by the company for improvements. The first proposal regards the usage of a different software for the collection of data since Excel is very limited for this kind of operations and is less user friendly than others business analytics software. It is not suggested for the elaboration of a huge amount of data and it requires a deep knowledge of the features in order to create an efficient program.

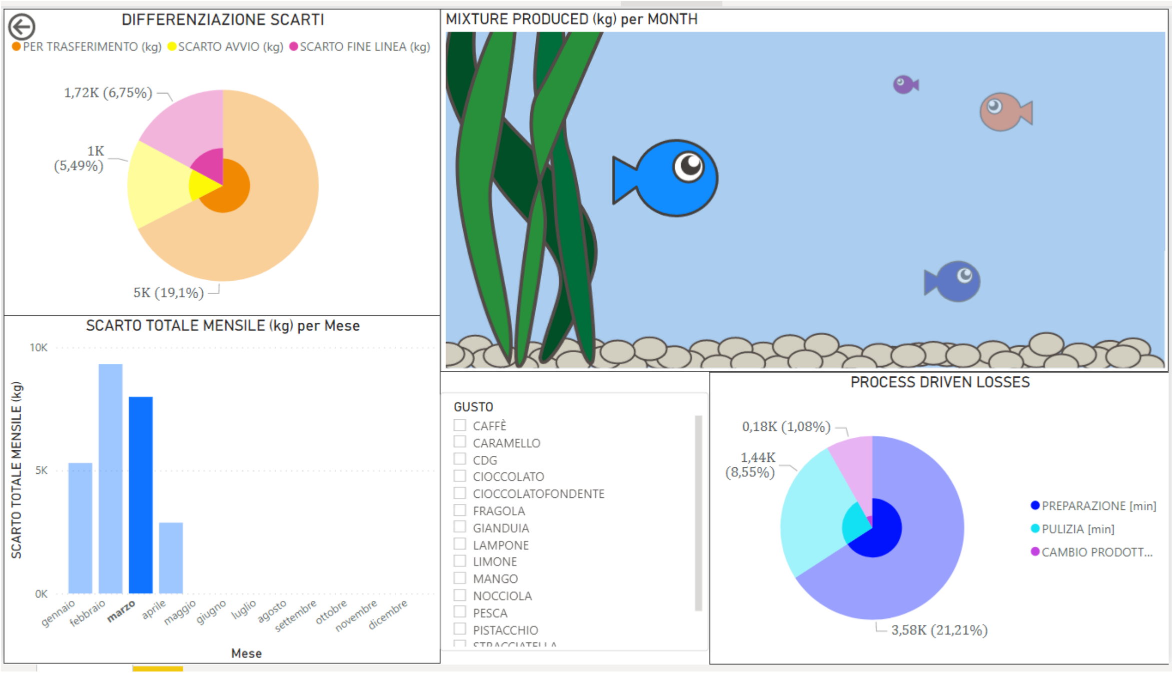
Another proposal, which is actually already in process, is the industrialization and automatization of the data collection, which lead to the elimination of human errors in the handwriting and to the gathering of information in real time. The name of the project is SCADA and it consists in linking the PLC of each machine in a unique informatic network, whose development requires the engagement of an informatic company and as consequence a huge budget. However, this could be the best possible, allowing the computation of KPIs for any instant and a quick detection of problems.

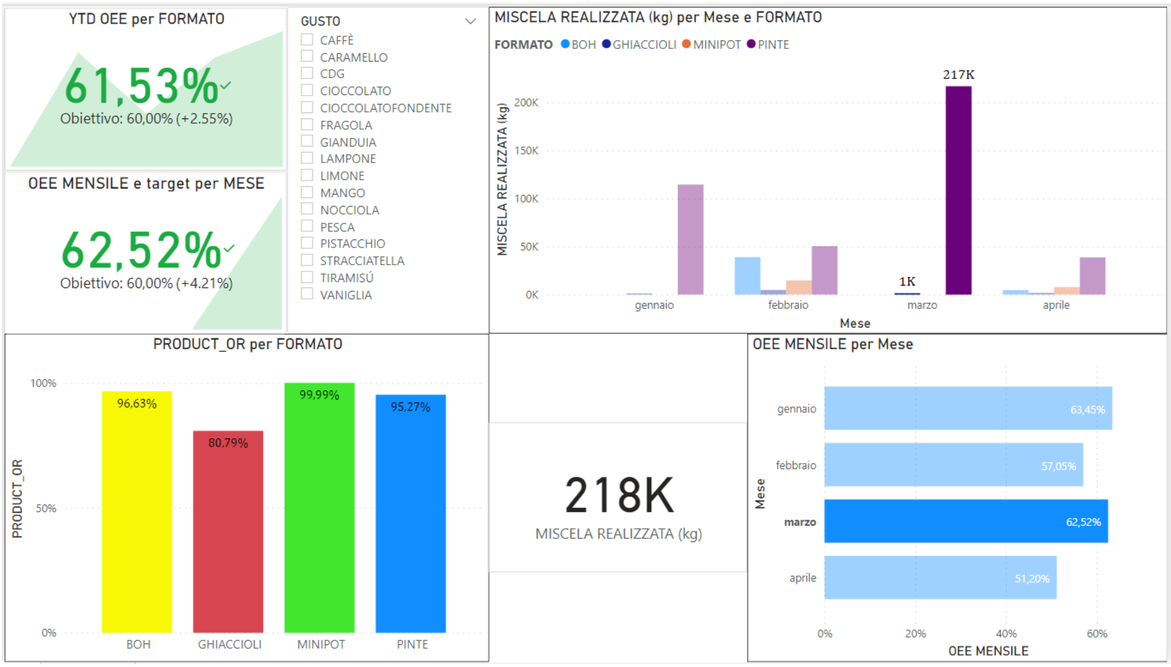
Appendix 1 - Dashboard on Power BI





Appendix 2 - Dashboard with application of filter "March"





Appendix 3 - Data about waste in March

MONTH	TYPOLOGY	MISCELA REALIZZATA (kg)	MISCELA TOT TANK (kg)	TRANSFER LOSSES (kg)	PERDITA TRASFERIMENTO %	PESO MISCELA CON GRANELLE (kg)	REWORK (kg)	FILLING LOSSES (kg)	END-OF-LINE (kg)	TOTAL LOSSES (kg)	TOTAL LOSSES %
marzo	PINTE	12225	11966	259	2,119%	12620,0	0	200	3,63	462,63	1,614%
marzo	PINTE	8164	8039	125	1,531%	8546,6	0	80	13,44	218,44	1,093%
marzo	PINTE	8752	8285	467	5,336%	9213,4	0	200	317,91	984,91	5,621%
marzo	PINTE	3957	3848	109	2,755%	4149,2	82	40	19,02	168,02	1,423%
marzo	PINTE	11301	11253	48	0,425%	11301,0	1104	200	34,85	282,85	2,078%
marzo	PINTE	9885	9815	70	0,708%	10217,5	0	180	17,42	267,42	1,932%
marzo	PINTE	8818	8394	424	4,808%	9277,9	0	0	6,97	430,97	0,075%
marzo	PINTE	9012	8695	317	3,518%	9482,5	0	0	7,37	324,37	0,078%
marzo	PINTE	3649	3512	137	3,754%	3812,3	26	0	24,49	161,49	0,642%
marzo	PINTE	3256	3199	57	1,751%	3674,0	58	0	0,00	57,00	0,000%
marzo	PINTE	9759	9385	374	3,832%	9759,0	0	60	128,71	562,71	1,934%
marzo	PINTE	8470	8296	174	2,054%	8923,1	0	0	13,48	187,48	0,151%
marzo	PINTE	8115	8153	0	0,000%	8115,0	0	0	5,02	5,02	0,062%
marzo	PINTE	4044	3942	102	2,522%	4130,4	0	0	5,02	107,02	0,122%
marzo	PINTE	1927	1927	0	0,000%	2019,8	0	0	4,83	4,83	0,239%
marzo	PINTE	6073	5867	206	3,392%	6291,9	66	0	14,75	220,75	0,234%
marzo	PINTE	10731	10419	312	2,907%	11106,8	0	0	9,82	321,82	0,088%
marzo	PINTE	1914	1901	13	0,679%	2006,0	37	0	18,52	31,52	0,923%
marzo	PINTE	7206	7208	0	0,000%	7206,0	779	20	131,20	151,20	2,098%
marzo	PINTE	11467	11269	198	1,727%	11467,0	0	120	18,26	336,26	1,206%
marzo	PINTE	2415	2408	7	0,290%	2415,0	57	0	6,72	13,72	0,278%
marzo	PINTE	6860	6605	255	3,717%	6929,0	55	0	0,68	255,68	0,010%
marzo	PINTE	8136	7817	319	3,921%	8466,0	38	0	13,22	332,22	0,156%
marzo	PINTE	8857	8985	0	0,000%	8857,0	154	60	67,70	127,70	1,442%
marzo	PINTE	9812	9379	433	4,413%	10179,6	0	0	41,32	474,32	0,406%
marzo	PINTE	3648	3557	91	2,495%	3820,0	0	0	18,16	109,16	0,476%
marzo	PINTE	8927	9061	0	0,000%	9095,9	0	40	24,83	64,83	0,713%
marzo	PINTE	9225	9069	156	1,691%	9571,7	0	50	31,66	237,66	0,853%
marzo	PINTE	10058	9842	216	2,148%	10670,1	0	150	28,14	394,14	1,670%

Appendix 4 - Data about KPIs in March

TYPOLOGY	Loading time	Units with Quality Defe	Tot units producec	(Good Volumes	VOT	MONTH	Preparatory & close out time	Changeover /Product chai	Cleaning & Sanitatio	Process Driven Losses	OT	Manufacturing performance losses	OEE	MP	SP	OR
PINTE	960	11	24491	24480	680,00	marzo	02:00:00	00:00:00	01:55:00	03:55:00	725	45,0	70,83%	93,79%	75,52%	100,00%
PINTE	960	44	25100	25056	696,00	marzo	04:00:00	00:00:00	00:38:00	04:38:00	682	14,0	72,50%	102,05%	71,04%	96,67%
PINTE	960	1056	24768	23712	658,67	marzo	03:00:00	00:00:00	00:48:00	03:48:00	732	73,3	68,61%	89,98%	76,25%	94,85%
GHIACCIOLI	300	812	18432	17620	271,08	marzo	03:00:00	00:00:00	01:55:00	04:55:00	5	266,0	90,36%	82,34%	88,56%	77,64%
PINTE	960	71	12127	12056	334,89	marzo	02:00:00	00:48:00	00:00:00	02:48:00	792	457,1	34,88%	42,28%	82,50%	99,14%
PINTE	960	107	23019	22912	636,44	marzo	02:00:00	00:00:00	00:30:00	02:30:00	810	173,6	66,30%	78,57%	84,38%	88,40%
PINTE	960	60	24324	24264	674,00	marzo	01:00:00	00:00:00	01:40:00	02:40:00	800	126,0	70,21%	84,25%	83,33%	84,25%
PINTE	960	25	26089	26064	724,00	marzo	03:00:00	00:00:00	01:25:00	04:25:00	695	29,0	75,42%	97,35%	72,40%	98,35%
PINTE	960	26	27322	27296	758,22	marzo	02:00:00	00:00:00	01:42:00	03:42:00	738	20,2	78,98%	94,22%	76,88%	99,77%
PINTE	960	119	20279	20160	560,00	marzo	04:00:00	00:30:00	00:50:00	05:20:00	640	80,0	58,33%	87,50%	66,67%	98,02%
PINTE	960	40	26160	26120	725,56	marzo	03:00:00	00:00:00	00:30:00	03:30:00	750	24,4	75,58%	96,74%	78,13%	100,00%
PINTE	960	620	25084	24464	679,56	marzo	03:00:00	00:00:00	01:00:00	04:00:00	720	40,4	70,79%	94,38%	75,00%	99,93%
PINTE	960	53	23741	23688	658,00	marzo	02:20:00	00:15:00	00:40:00	03:15:00	765	107,0	68,54%	86,01%	79,69%	93,53%
PINTE	960	65	21849	21784	605,11	marzo	04:50:00	00:00:00	00:38:00	05:28:00	632	26,9	63,03%	95,75%	65,83%	99,15%
PINTE	960	31	27391	27360	760,00	marzo	01:30:00	00:00:00	00:35:00	02:05:00	835	75,0	79,17%	91,02%	86,98%	100,00%
PINTE	960	643	20643	20000	555,56	marzo	02:40:00	01:00:00	00:50:00	04:30:00	690	134,4	57,87%	80,52%	71,88%	81,70%
PINTE	960	72	25992	25920	720,00	marzo	01:35:00	00:00:00	01:10:00	02:45:00	795	75,0	75,00%	90,57%	82,81%	100,00%
PINTE	960	32	10936	10904	302,89	marzo	00:30:00	00:05:00	00:50:00	01:25:00	875	572,1	78,09%	85,68%	91,15%	94,00%
PINTE	960	49	22737	22688	630,22	marzo	03:25:00	00:00:00	01:19:00	04:44:00	676	45,8	65,65%	93,23%	70,42%	92,60%
PINTE	960	208	19944	19736	548,22	marzo	01:15:00	00:00:00	01:10:00	02:25:00	815	266,8	57,11%	67,27%	84,90%	90,37%
PINTE	960	119	27479	27360	760,00	marzo	01:45:00	00:00:00	01:10:00	02:55:00	785	25,0	79,17%	96,82%	81,77%	100,00%
PINTE	960	159	11808	11649	323,58	marzo	02:00:00	00:25:00	01:10:00	03:35:00	745	421,4	33,71%	43,43%	77,60%	98,88%
PINTE	960	106	3166	3060	85,00	marzo	03:20:00	00:00:00	00:38:00	03:58:00	722	637,0	49,89%	66,34%	75,21%	100,00%
PINTE	960	110	23358	23248	645,78	marzo	02:30:00	00:00:00	01:00:00	03:30:00	750	104,2	67,27%	86,10%	78,13%	99,86%

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