

Enhancing Manufacturing Performance in Cork Stopper Production: Planning Tools for WIP and Service Level Improvement

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" It is not the strongest of the species that survives, nor the most intelligent that survives. It is the one that is most adaptable to change." - Charles Darwin

Melhoria de Desempenho na Produção de Rolhas de Cortiça: Ferramentas de Planeamento para Redução de WIP e Melhoria dos Níveis de Serviço

Resumo

SOCORI, uma fábrica de rolhas do grupo Bourrassé, operava historicamente sob um modelo produtivo semelhante a um modelo Push, coordenado pela empresa-mãe em França. Este modelo envolvia o envio de toda a produção, independentemente da procura real do mercado, para a sede do grupo em França. Com a aquisição do grupo Bourrassé pela Amorim Cork, foi implementada uma mudança significativa para um modelo de produção mais alinhado com o mercado (Pull). Esta transição visa alinhar a produção mais de perto com as necessidades reais do mercado, aumentar as intenções de produção e vendas para os próximos anos e reduzir Slow Movers dentro da cadeia produtiva. Consequentemente, esta nova abordagem coloca uma pressão adicional sobre toda a cadeia de produção e logística, necessitando de melhorias no planeamento de toda a cadeia produtiva.

Este projeto, desenvolvido no Departamento de *Supply Chain* da U.I. SOCORI, teve como objetivo criar ferramentas de planeamento para utilização de dados MES e SAP, reduzindo os níveis de WIP e melhorando os níveis de serviço. Os principais objetivos incluíram identificar os *bottlenecks* de produção, reduzir a produção de *Slow movers* e garantir a avaliação regular e a utilização das soluções desenvolvidas por todas as partes interessadas. Em última análise, o projeto procurava melhorar o serviço ao cliente, otimizar a gestão de inventário e simplificar os processos de produção.

Dentro das três famílias de rolhas de cortiça, rolhas aglomeradas, técnicas e naturais que são produzidas na Unidade Industrial, foi dado ênfase ao setor de rolhas de cortiça aglomeradas devido a esta secção ser responsável por um maior volume de vendas, bem como por fornecer corpos de rolhas de cortiça para o setor de produção de rolhas técnicas.

Durante este projeto, foi feita uma análise de *bottlenecks* ao setor, revelando que este bottleneck depende do artigo específico, uma vez que o mesmo artigo pode ter diferentes cadências de produção em cada processo, devido a razões de compatibilidade relacionadas com as propriedades da rolha, como a mistura de cola-cortiça e a dimensão. Apesar deste facto, o gargalo geral identificado foi o primeiro processo, a máquina de moldação. Após a análise dos gargalos, foi criado um VSM, resultando em *insights* sobre desperdícios relacionados com níveis excessivos de WIP.

Foram desenvolvidas um total de quatro soluções: um Sistema de Planeamento de Cartões de Produção, uma ferramenta de planeamento para gestão da capacidade do processo de maquinagem, uma melhoria operacional no processo de maquinagem e, por último, uma ferramenta de visualização do estado da qualidade de inventário, principalmente desenvolvida em Microsoft PowerBI. As quatro soluções visaram resolver três problemas principais: 1. Produção de *slow movers* 2. Capacidade de maquinagem desnivelada, que dependia muito do tamanho inicial do produto, bem como da geometria final desejada, e 3. Falta de visibilidade sobre o estado de qualidade do inventário.

No final do projeto, todas as quatro soluções estavam a ser utilizadas pelos seus respetivos *stakeholders*, com os níveis de stock excessivo identificados a serem quantificados no total de 7,111 milhões de rolhas. As ferramentas de planeamento contribuíram ainda para um melhor fluxo de informações, permitindo atribuições de pedidos e ações corretivas mais rápidas, reduzindo o tempo de resposta ao mercado. Adicionalmente, o projeto contribuiu para a normalização do fluxo de informação e redução de desperdícios relacionados com erros, como ações corretivas sem valor acrescentado ou produção de *slow movers*.

Abstract

SOCORI, a cork stopper manufacturing plant within the Bourrassé Group, has historically operated under a production management model resembling a push approach, directed by the parent company in France. This model involved sending all production, regardless of actual market demand, to the group's headquarters in France. With the acquisition of the Bourrassé Group by Amorim Cork, a significant shift towards a more market-aligned (Pull) production model was implemented. This transition aims to align production more closely with market needs, increase production and sales intentions for the coming years, and reduce Slow movers. Consequently, this new approach puts additional pressure on the entire production and logistics chain, necessitating improvements in the planning of the entire production chain.

This project, developed in SOCORI's Supply Chain Department, aimed to create planning tools to leverage MES and SAP data, reducing WIP levels and improving service levels. Key objectives included identifying production bottlenecks, reducing Slow Mover production and ensuring regular utilization of the developed solutions by all stakeholders. Ultimately, the project sought to enhance the unit's service level, optimize inventory management, and streamline production processes.

Within the three cork stoppers families, agglomerate, technical and natural that are produced in the Industrial Unit, an emphasis on the agglomerate cork stopper sector was opted due to this section being responsible for a higher sales volume as well as being responsible for supplying the technical cork stopper production sector.

During this project, a bottleneck analysis was made to the sector, revealing that this bottleneck depends on the specific item, as the same item has different rates of production in each process, due to compatibility reasons regarding the cork's properties such as cork-glue mix and dimension, however, the overall bottleneck that was identified was the first process, the moulding machine. After the bottleneck analysis, a VSM was created, resulting in valuable insights into excessive WIP levels.

A total of four solutions were developed, namely, a production card planning system, a planning tool for managing machining capacity, an operational improvement in the machining section and lastly a quality status visualization tool mainly developed in PowerBI. The four solutions aimed to solve three main problems: 1. Slow mover production 2. Unlevelled machining capacity, which was highly dependent on the product initial size as well as the desired final geometry and 3. Lack of visibility on inventory quality status.

By the end of the project, all four solutions were being utilized by their targeted stakeholders, with the targeted wastes being quantified in a total of 7.111 million cork stoppers reduction, the planning tools further contribute towards an enhanced information flow, allowing quicker order assignments and corrective actions, reducing time to market. The project also contributed by standardizing information flow and reducing mistake related wastes, such as additional non-value-added tasks or overproduced Slow Movers.

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Abbreviations

ATO – Assemble to Order

CODP – Customer Order Decoupling Point

CONWIP - Constant Work In Progress

C. S. – Cork Stopper

DBR – Drum-Buffer-Rope

EBITDA – Earnings before interest, taxes, depreciation, and amortisation

ERP – Enterprise Resource Planning

ID – Identification

JIT – Just In Time

KPI – Key Performance Indicators

MES - Manufacturing Execution System

MTO – Make to Order

MTS – Make to Stock

OPP – Order Penetration Point

PDCA – Plan Do Check Act

POLCA – Paired-cell Overlapping Loops of Cards with Authorization

RBC – Repeat Business Customizers

TCA – Trichloroanisole

TOC – Theory of Constraints

VMC – Versatile Manufacturing Companies

VSM – Value Stream Map

WIP – Work In Progress

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1 Introduction

1.1 Company Presentation

Corticeira Amorim SGPS S.A. is the world's biggest cork processing group. Founded in 1870, the group made unprecedented investments in research and development as well as overall innovation creating a wide portfolio of products and solutions with high added value (Corticeira Amorim SGPS S.A., n.d.).

In Corticeira Amorim group, each company integrates 1 of 5 Business Units (Corticeira Amorim SGPS S.A., 2022):

1. Raw Materials
2. Cork Stoppers
3. Cork Flooring
4. Composite Agglomerates
5. Insulation

Corticeira Amorim's business unit EBITDA in 2022 can be seen in Figure 1 (Corticeira Amorim SGPS S.A., 2022). As it can be seen, the Cork Stopper Business Unit alone is responsible for 75% of the group's EBITDA, the group alone owns 44% of the global cork stopper market share (LJUBENOVIC, 2019).

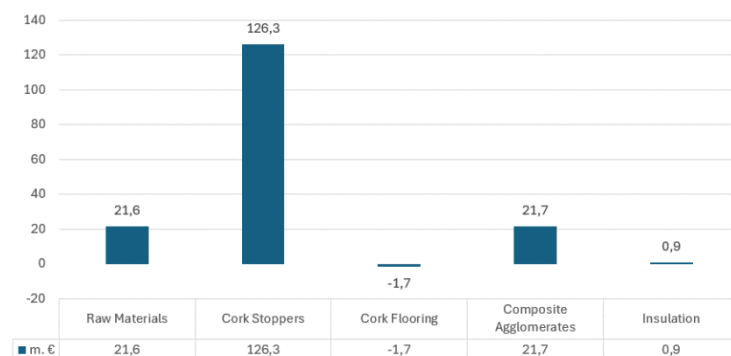


Figure 1: Corticeira Amorim group Business Units EBITDA 2022

On July 19th, 2017, Corticeira Amorim SGPS S.A., through its subsidiary Amorim & Irmãos, SGPS, S.A., has signed an agreement to acquire the share capital of the company ETABLISSEMENTS CHRISTIAN BOURRASSÉ (société anonyme), based in Tosse (France), which holds the entire share capital of SOCORI – SOCIEDADE DE CORTIÇAS DE RIOMEÃO (Amorim Cork, 2017). ETABLISSEMENTS CHRISTIAN BOURRASSÉ (société anonyme) will be referred as BOURRASSÉ and SOCORI – SOCIEDADE DE CORTIÇAS DE RIOMEÃO as SOCORI.

Created in 1988 by the French group ETABLISSEMENTS CHRISTIAN BOURRASSÉ S.A., SOCORI is located in Rio Meão, Santa Maria da Feira, Aveiro and fabricates more than 700

million cork stoppers to more than 3300 customers which are then sold by BOURASSÉ that operates mainly in France, Spain, Italy, and Chile (Amorim Cork, 2017).

The brand and values of BOURASSÉ were safeguarded and the acquisition aims to ensure the continuity of the company's identity and autonomy (Amorim Cork, 2017).

Currently, the productive process of SOCORI includes the whole cork stopper fabrication value chain, from the purchase of raw materials, processing, marking, and packaging, which is then commercialized by BOURASSÉ, giving the group total control of the entire cycle relating the production and sale of cork stoppers (Amorim Cork, 2017).

While CORTICEIRA AMORIM, S.G.P.S., S.A. integrates many industrial units and has the Amorim brand on its products, BOURASSÉ is operated independently, competing in some common markets, with different production approaches and products.

1.2 Context and motivation

Before the acquisition, SOCORI's production model was based on a Push approach, where production was sent to the stock point in France with little regard to real market needs. With the BOURASSÉ group's acquisition by the Amorim Group, a new management approach was adopted to align production more closely with market demand, reduce Slow movers, and create a leaner supply chain.

With the acquisition, a digital transformation process was carried out, integrating the MES system (Manufacturing Execution System) and migrated to the ERP system (Enterprise Resource Planning) SAP. This aimed to standardize the production management processes of the industrial unit with those of other plants in the Amorim Group, thereby enhancing the availability and accessibility of production data. The increased availability of data made it imperative to extract maximum value from it, enabling data-driven decisions that promote continuous improvement, operational efficiency, and flexibility in responding to market changes in both product mix and SKU quantities.

It is in this context that this project arises. The project was developed in the Supply Chain Department of SOCORI. It aims to develop planning tools to ensure smooth data flows and empowering data-driven decisions that ultimately will contribute to reduce WIP and improve the units Service Levels, contributing to the larger goal of a Push to Pull transition for the Industrial Unit.

1.3 Project's objectives

As mentioned above, the project is part of the broader goal for the Industrial Unit to transition from a Push approach to a more market-oriented Push-Pull approach. The first objective is to identify production bottlenecks and waste within the unit's manufacturing chain.

To achieve a leaner production chain, the project aims to leverage data from the MES and SAP systems by developing planning tools that enable data-driven decisions. These tools will ultimately aid in reducing WIP levels and/or improving the Level of Service. However, the project may focus on only one of these objectives.

A key driver of this initiative is addressing Slow movers. The project aims to identify and reduce Slow Mover production levels by at least 50%.

An essential aspect of the project's success lies in ensuring regular assessment and utilization of the developed solutions by planning stakeholders, including the supply chain department, as well as all affected production planners.

Regarding the implementation stage, it is expected that all tool development will be completed by the end of the project. The potential impact of each tool should be fully tracked and quantified in terms of WIP% decrease and other service level indicators such as Production Lead Time improvement.

In summary, the project aims to enhance client service levels, optimize inventory management, streamline production processes, and foster a culture of continuous improvement within SOCORI Industrial Unit.

1.4 Methodology

The overall project's Gantt Chart can be seen in APPENDIX A: Project Development Gantt Chart.

The first two weeks of the time spent in the company were organized by the Cork Talent program. An introduction to the overall Amorim Cork Industrial Units was conducted, visiting in total 14 Industrial Units and understanding the several business models and general cork stopper processing methods and product range. In February 20th, the project officially started with the integration in SOCORI's Supply Chain department.

During the first two weeks the goal was to get to know the used planning tools, namely, the MES database (Manufacturing Execution System) and SAP database as well as the specific processes regarding the agglomerate and technical section processes.

Starting in March 4th, the purpose was to define the current state of processes, decisions and global performance, which was concluded in April 5th. This phase's main deliverable was the bottleneck analysis and VSM (Value Stream Map).

From April 8th onwards the focus was to identify improvement opportunities that would ultimately lead to a WIP Inventory decrease and an overall improvement upon the current planning methods as well as conducting their development. This phase only ended in March 31st.

Starting on June 3rd, the planning tools were implemented and enhanced to better meet stakeholders' needs. Results were collected, and the impact of each tool was analysed and predicted.

1.5 Structure of the document

The dissertation is divided into five chapters. After this first introductory chapter, Chapter 2: Bibliographic Review is an overview on the theoretical concepts that are relevant to this project, that served as the foundation for the decisions made throughout the project.

In Chapter 3: Problem Description, the current situation within SOCORI Industrial Unit is explained, the various products are explained as well as their manufacturing steps and a further capacity and inventory analysis were conducted, culminating in a section bottleneck analysis and a VSM (Value Stream Map) which was also further analysed in Chapter 4.

Chapter 4: Proposed Solutions and Benefit Analysis is composed of three parts, each describing the motivations behind each solution, the solution itself and the results and benefits to the industrial unit. This chapter further elaborates upon the data collected in Chapter 3 and includes an initial action plan synthesis on the solving of each identified improvement opportunity.

Finally, in Chapter 5: Conclusions an overview on the project's goals and accomplishments is conducted resulting in an overall assessment of the project's success.

2 Literature Review

2.1 MTS and MTO Manufacturing

MTS (Make to Stock) is a conventional production strategy that is used by businesses to match inventory with anticipated customer demand, instead of fixing its production level and trying to sell the produced products, this approach uses statistical method to make projections about the final product inventories and then supply enough stock to meet those projected orders (Segal, 2022).

Some of the benefits of MTS companies are the ability to use production resources more efficiently, allowing to level the production capacity to maximize asset utilization, it is especially relevant in industries in which skill requirements limit the availability of contract labour. It also has the advantage of simplifying production timings, since what needs to be produced is scheduled in advance, work can progress smoothly according to schedule, giving the company more time to plan out its production. One of the most relevant benefits of MTS business models is that since significant finished goods inventories are kept to meet customer demand, the lead time to meet a customer order does not include any manufacturing activity, since the items are already available in stock, timings are therefore shorter and only dependant of stock location and travel time to the final destination (Corporate Finance Institute, n.d.-b)

A significant disadvantage of MTS business models is the risk of potential lost sales or inventory becoming obsolete, depending on the accuracy of the consumer demand forecasts and if it overestimates or underestimates consumer demand (Timberg, 2024).

MTO (Make to Order) is a production strategy in which the production of an item begins only after a confirmed customer order is received, allowing for tailored manufacturing to the customer needs (Hayes, 2024).

Stevenson et al. (2005) classify MTO businesses into two types depending on their market: Repeat Business Customizers (RBC) and Versatile Manufacturing Companies (VMC). RBC businesses provide customized products to clients based on a contract with a defined length, providing some predictability over the demand, these businesses typically include bigger batches that can repeat themselves over the contracted period. VMC businesses are typically more complex, where each order is unique, providing a wider range of product variety, manufacturing in smaller batches with little repetition, therefore, VMC market demand is inherently harder to predict (Stevenson et al., 2005).

Considering that MTO companies assure that produced products have an allocated order, benefits of MTO companies therefore include the significant reduction of other wastes associated with inventory obsolescence. One of the most relevant benefits of this approach is that since production is pulled by an allocated order, it also offers a greater variety of products, providing customers exactly what they want (Corporate Finance Institute, n.d.; PLANETTOGETHER, 2021).

MTO business models also include several drawbacks, such as the inability to level production, leading to periods of high sales and low sales volume, which are not predicted in advance, it also has an inherent bigger lead time to meet a customer order, since the manufacturing process only starts when the order is placed, production times can also be greater than the MTS approach, since MTO allows for a greater product variety, customization usually takes longer due to setup times. Since MTO models do not heavily rely on demand forecasts, the uncertainty of demand raises the necessity of keeping sufficient supply of raw materials so that production can start immediately after an order is received (Corporate Finance Institute, n.d.; Timberg, 2024).

In today's global market landscape, characterized by intense competition and rapid technological advancements, customer expectations have increased. Consumers now demand not only high-quality products at competitive prices but also a steady stream of innovative new offerings from every brand. Due to the consumers expectations of new models by each brand, the perishability of products has increased, increasing the difficulty of predicting market demand accurately, it also led to significantly increasing the risk of inventory obsolescence in case of overproduction. As a result, companies nowadays compete not only in quality and price, but also in terms of flexibility and adaptability to the market, increasing the attractiveness of the MTO business model, and consequently, the number of MTO manufacturing companies (Saniuk & Waszkowski, 2016).

2.2 Customer Order Decoupling Point

In the context of the manufacturing value chain, the order penetration point (OPP) or customer order decoupling point (CODP) represents the juncture where the manufactured product becomes associated with a specific customer order, dividing the manufacturing stages in two parts, the upstream stages, which are forecast-driven and the downstream stages, which are customer-order-driven (Cannas et al., 2019).

The positioning of the CODP can be used as a defining characteristic of each manufacturing strategy, differentiating MTO, MTS, and other strategies like assemble-to-order and engineer-to-order, see Figure 2 (Olhager, 2003).

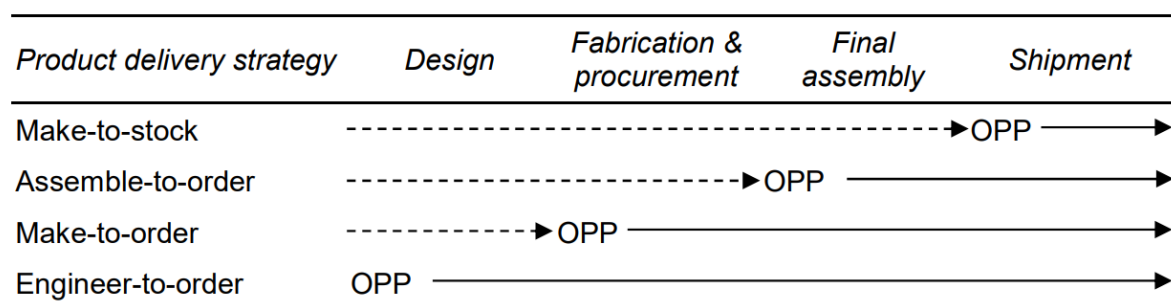


Figure 2: Different product delivery strategies' CODP (Olhager, 2003).

As seen in Figure 2, in an MTS business model, the CODP is placed in a later production stage after the whole manufacturing process has been completed, therefore, when a customer places an order, the finished good is ready in inventory and is shipped to the client accordingly. MTO business models, on the other hand, have their CODP placed in a much earlier production stage, before the manufacturing process has occurred, only when a customer has placed an order can the manufacturing process begin, after which the product is shipped to the customer accordingly.

Assemble-to-order business models allocate the product to the client at the middle of the manufacturing process, where each part of the final product has already been manufactured, but

the final assembly is waiting for the customer order to start, allowing the company more versatility to customize the final product than the one available in the MTS approach, but decreasing the delivery lead time in comparison to the MTO approach where the manufacturing of parts would only start after the customer order was placed. Engineer-to-order business models, however, design the product according to clients' specifications, making the CODP as early as the design phase, even earlier than the MTO approach.

While cost and productivity are the most important performance measures for upstream operations; flow time speed and flexibility (ability to adapt to different product mix and volume) become crucial for downstream operations, since they are crucial to have the necessary responsiveness to customer demand, delivering products as fast as possible. There are two major driving forces to shifting the CODP forwards, the first one is to reduce delivery time to customers as well as delivery reliability; the second one is to increase manufacturing efficiency by optimizing bottleneck operations, and therefore, reducing the product's final price. Moving the CODP forward is typically achieved by increasing the level of pre-fabrication such as introducing modular design concepts. On the other hand, shifting the CODP backwards offers more knowledge of the customer order during the manufacturing process, allowing for a higher degree of customization and to reduce the amount of work-in-process inventory as well as minimizing the need for finished goods inventory and consequently, the risk of obsolete materials. Moving the CODP backwards requires significant lead time reduction of downstream activities, in order to maintain the delivery lead time while performing production activities with a higher degree of customer customization (Olhager, 2003).

2.3 Lean Manufacturing

Lean manufacturing is a production philosophy that aims the production of goods through removal of waste, focusing mainly on the reduction of the seven wastes originally identified by Toyota (Kosky et al., 2020).

The seven wastes identified by Toyota are the following (Arunagiri & Gnanavelbabu, 2014):

1. Transportation, waste related to unnecessary movement of raw materials, WIP or finished goods, caused by excessively long routes or routes performed in an inefficient frequency, resulting in increased transportation costs, as well as any possible delays it can cause in production, increasing wait times and, therefore, WIP inventory as well.
2. Inventory, waste related to the storage of raw materials, WIP and finished goods in quantities that go beyond supporting the immediate need of production, increasing capital invested in inventory, and consequent cost of opportunity of investments elsewhere within the company as well as increasing the risk of inventory obsolescence expenses and inventory holding costs.
3. Motion, waste related to non-value-added movements of workers that are unnecessary within the manufacturing plant, resulting in possible processing delays, loss of production capacity or the ineffective use of employees' time, skills and ideas.
4. Waiting, time when work-in-process is waiting for the next step in production typically as a result from processing delays and system / machine downtime.
5. Overproduction, waste associated with the production of an excessive amount of finished goods, usually caused by the production of items ahead of demand, resulting in an increased risk of inventory obsolescence expenses and inventory holding costs
6. Overprocessing, waste of time and resources in processing more than required to achieve what the customer requires, usually a result of manufacturing specifications – customer requirements misalignment.

7. Errors and defects, associated with the production of items that do not meet manufacturing specifications, typically resulting in additional rework, inspection, design changes, process changes and machine downtime to analyse problems, resulting in significant operational costs.

Kosky et al. (2020) further explained that lean manufacturing focuses in getting to the right things, at the right time, in the right quantity to achieve optimal workflow while at the same time minimizing waste and promoting flexibility to adapt to demand behaviour changes. Not only should parts arrive at a workstation just in time to be consumed in the process, but also the factory should produce finished products just in time to be handed to a waiting customer, therefore reducing inventory of raw materials, parts and finished goods. The principles of lean manufacturing are zero waiting time, zero inventory, internal customer pull instead of push, reducing batch size and reducing process times (Kosky et al., 2020).

2.4 Push vs Pull Systems

Push is a production system in which when a job is completed in a workstation, it is pushed to the next one to be further processed, following a pre-determined sequence of stages before final completion, regardless of workstation capacities and inventory levels. On its essence, the push production system has no explicit limit on the amount of WIP that can be in a system. On the other hand, Pull is a production system where each job is withdrawn or pulled by its succeeding workstation. The flow of parts throughout the line is commonly controlled by Kanban Cards. However, more broader definitions defined Pull systems as one that explicitly limits the amount of WIP inventory that can be in the system, therefore, Kanban is one of many possible Pull production systems, such as CONWIP and POLCA approaches (Kumar & Panneerselvam, 2007).

2.4.1 KANBAN Methodology

Kanban methodology is a means of implementing JIT, focusing on the reduction of waste in the forms of over-production, unnecessary motion, defects, over-processing and waiting (Raut et al., 2015).

The two-card kanban method originally developed by Toyota Motor Corporation is based on the principle that production could not begin without a production card, a container of the appropriate incoming parts and an idle work station. The two-card kanban method works as follows, see Figure 3 (Hopp & Spearman, 2004).

A. Processing

1. Worker at station $i+1$ removes the container from its Inbound Stock Point $i+1$ and starts processing it's parts according to the Production Card in the Production Cardboard $i+1$.
2. When parts are processed, the container is moved to the Outbound Stock Point $i+1$.

B. Material Movement

1. Initially, when the worker at station $i+1$ removes container from its Inbound Stock Point $i+1$ he also places it's Move Card into the Move Cards hopper $i+1$. This signals which parts he needs from the previous upstream operations.
2. Worker at station $i+1$ collects the Move Cards in the Move Cards hopper $i+1$.
3. Worker at station $i+1$ removes the container from the Outbound Stock Point at station i and places a Production Card in the Production Cardboard i , signaling previous upstream operation what parts need to be processed.
4. Worker at station $i+1$ moves the container from the Outbound Stock Point i to the Inbound Stock Point $i+1$.

A Two-Card Kanban System

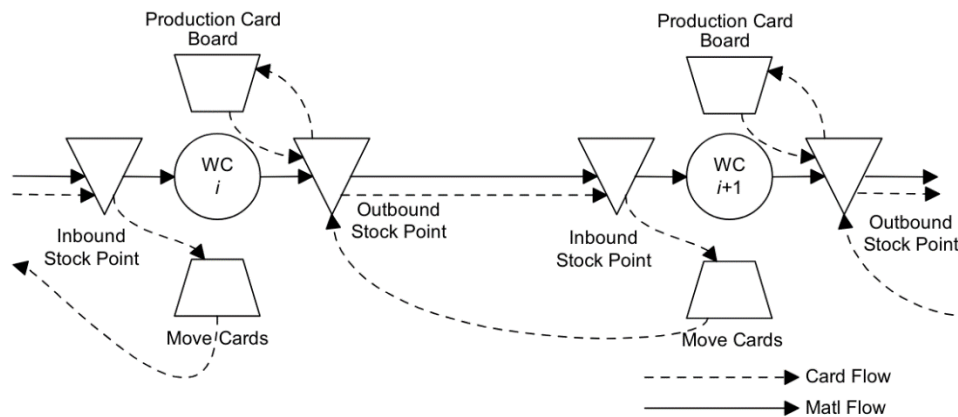


Figure 3: A Two-card Kanban system (Hopp & Spearman, 2004).

The two card kanban system results in a FIFO (first in, first out) dispatching rule distinction between parts processing and material movement, resorting to Production Cards and Movement Cards as a method to achieve a serial production system with blocking (Hopp & Spearman, 2004).

The kanban system results in several key benefits (Hopp & Spearman, 2004; Raut et al., 2015):

1. Reducing WIP and Cycle Time, by limiting production releases into the system, kanban regulates WIP, resulting in a lower average WIP level and, consequently, translates to shorter manufacturing cycles.
2. Smoother production flows, short queues reduce the time between the creation and detection of a defect.
3. Increasing operational efficiency, by switching control from a Push approach to a Pull approach (WIP is limited by the number of KANBANS), problems result in the form of blocking and starving of the line, requiring fixing before the production process can continue flowing. The solving of these problems that otherwise could easily remain undetected results in more efficient systems with lower production costs.

The two card kanban system is, however, limited to a restrained ammount of production environments, being associated with repetitive manufacturing, it is intrinsicly unable to meet a manufacturing environment controlled by shop orders, where production is less repetitive and more variable. Therefore, researchers tried to find different production systems within the Pull Production Systems to implement this methodology in a bigger range of companies and to be able to cope with more variability than the classic Kanban methodology. Two of those innovations were the concepts of the POLCA and CONWIP production systems (Spearman et al., 1990).

2.4.2 CONWIP Production System

Spearman et al., (1990) developed a system that possesses the benefits of a pull system but was additionally compatible with a wider range of manufacturing environments, calling it the CONWIP Production System, CONWIP standing for Constant Work In Process. As the name entails, the main goal of a CONWIP Production System is to control the amount of work on the environment by keeping it constant.

Contrarily to the two card KANBAN system, CONWIP systems only rely on 1 set of cards, production cards. These cards are assigned a standard container to a production line and accompany parts throughout all the processes within the production line, from start to finish (Spearman et al., 1990).

When a container finishes to be processed the card is removed from the container and returns to beginning of the line where it waits in a card queue to eventually be attached to another container of parts. The assignment of cards is controlled by a backlog list, which represent a production queue. Maintenance of the backlog should be the responsibility of production and inventory control staff, where is most cases the backlog would be generated from a master production schedule. Expeditors should have the capability of rearranging backlog and/or part numbers to it, however, under no circumstances could they force the start of work without a card present, regardless of process capacity utilization levels (Spearman et al., 1990). Although work is processed according to the backlog list, the highest priority is given to rework orders, ensuring the FIFO approach of the system.

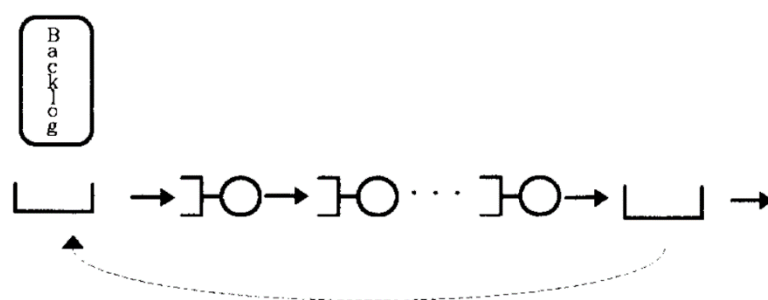


Figure 4: CONWIP system (Spearman et al., 1990).

The CONWIP system is therefore based in a FIFO (First In First Out) approach, meaning that when work enters the production line it is processed before any work that entered after, and before any work that entered before in every process step of the production line.

The level of WIP within the CONWIP system is controlled by limiting the number of cards inside the production line, therefore making it a Pull System, although the work is pushed within the production line, the first station requires a pull signal that allows work to enter the production line.

One limitation of the CONWIP system is that it requires for workload of each card to be similar, therefore requiring some standardization of products and moving loads in order to be applicable.

The CONWIP system was originally designed for manufacturing environments with few routes, similar processing times and linear process flows, therefore, some other limitations regarding its applicability include: 1) Line Order is undetermined as CONWIP cards pass through multiple stages, 2) Backlog information is not retained and is not utilized for WIP regulation. Therefore, it's implementation should consider its applicability in each production context and modifications to the original system may be required to make its application viable. (Prakash & Chin, 2014).

2.5 Theory of Constraints

Theory of Constraints (TOC) is a management philosophy and methodology developed by Eliyahu M. Goldratt in the 1980s, TOC seeks to identify constraints or bottlenecks within a system to improve system's performance and achieve organizational goals (Theory of Constraints Institute, n.d.).

Originally, TOC focused on planning the production process and allocate resources. Over time it has evolved becoming a management philosophy applicable to every sector within a company, regardless of company size, therefore being applied in production, logistics, supply chain, distribution, project management, accounting, research and development, sales, and marketing as well as other sectors. TOC is based on the principle that every system has a least one bottleneck or weakest point, with bottleneck being defined by the Oxford English Dictionary as "anything that delays development or progress". Şimşit et al. further elaborate that everything which exists in the road of having more profit is considered a constraint, therefore, managing these constraints leads to continuously improving towards achieving higher profits (Şimşit et al., 2014).

2.5.1 Drum-Buffer-Rope

Within any system, whether it's a manufacturing process, product development project or even any daily routine, tasks can be categorized into two main types: bottleneck and non-bottleneck tasks. A bottleneck task is any task that limits the overall throughput or capacity of the system, typically being characterized by having the longest processing time within the system, or being the task with smaller capacity. Non-bottleneck tasks are the remaining tasks that do not limit the flow of work, these task's cadency is limited by the bottleneck capacity, regardless of it's own (Theory of Constraints Institute, n.d.).

Understanding and distinguishing between these tasks is crucial for optimizing and maximizing system capacity, as improving non-bottleneck capacity does not result in a system capacity increase. Focusing attention and resources on bottleneck tasks, organizations can alleviate constraints and increase overall throughput. This may involve reallocating resources, streamlining processes or implementing technological solutions to improve bottleneck capacity (Gundogar et al., 2016).

One methodology for managing tasks is the Drum-Buffer-Rope (DBR) theory, introduced by Eliyahu M. Goldratt as part of his Optimized Production Technology, providing a systematic approach to scheduling and prioritizing work to optimize the flow of production. The "drum" represent the bottleneck or capacity-constrained resource. All activities should be synchronized around the drum to ensure a steady flow of work and prevent WIP build up. Buffers are the inventory levels required to maintain consistent production, assuring that brief interruptions and fluctuations in non-bottleneck tasks do not affect the bottleneck tasks, more variation requires

larger buffers. The “rope” symbolizes the release of work into the system based on the availability of the bottleneck resource, ensuring that work-in-progress is controlled and aligned with the capacity of the bottleneck. The application of DBR allows organizations to effectively manage bottleneck tasks and maximize throughput, minimizing inventory build up and delays (Vorne Industries Inc., n.d.).

2.6 Value Stream Map

The Value Stream Map (VSM) is a flowcharting tool used to visually represent the sequence of operation steps within a production flow. With the goal of revealing waste within the manufacturing process, VSM enables organizations to pinpoint non-value-added activities and opportunities for process simplification and streamlining, facilitating waste reduction and operational efficiency enhancement through further implementation of lean principles (Gunaki et al., 2022).

The outcome of a VSM is a chart presenting value flow within the company, final product and WIP inventories as well as finding out total manufacturing lead-time, differentiation value-adding tasks from non-value-adding tasks (Rohac & Januska, 2015). The icons used in a VSM graph for representing each element within the value chain can be seen in Figure 5.

Purchaser Supplier	Department	Purchase	Warehouse	Electronic information	Operational communication	Process	Inventory
Transport flow	Consumption	Information	Signal supply	PUSH	PULL	Traffic kanban	Consumption kanban
Production Kanban	Batch to expedition	Lorry Transport	Mech. handling	Handling	Conveyor	VA line	Shift foreman

Figure 5: Icons used in Value Stream Mapping (Rohac & Januska, 2015).

Rohac & Januska, (2015) further elaborate on the significance of inventories as the most crucial non-value-added component within Value Stream Mapping (VSM). The value of these inventories is quantified by the duration they remain at a given location, determined by the production takt time. This is calculated by the number of stored items divided by their daily consumption rate. The primary objective of VSM is to identify and eliminate waste, including overproduction, excess inventory and waiting times. One of the key missions of VSM is to reduce excessively high inventory levels, contributing to a shorter time-to-market and enabling more effective use of reallocated revenue, ultimately reducing waste and supporting a leaner manufacturing value chain.

2.7 Continuous Improvement

Continuous improvement, commonly known by the Japanese term "Kaizen" (Kai – change, Zen – good), stands for "change for the better". More than a management approach, Kaizen is a philosophy embraced in daily life in Japan, emphasizing gradual and continuous progress (Tatiana et al., 2007).

Within the management and manufacturing fields, continuous improvement is an approach that involves a consistent, never-ending effort towards manufacturing excellence involving everyone in the organization. This approach is crucial in the current competitive manufacturing landscape, serving as one of the fundamental strategies for achieving operational excellence (Schroeder & Robinson, 1991).

Continuous improvement's core principles include:

1. **People participation**
As the foundation of a company, workers' valuable knowledge and experience are a core asset towards improving upon the status quo (Bond, 1999; Hall, 1987).
2. **Factual decision-making**
Continuous improvement requires effective decisions and actions, which rely on data-analysis. This core principle firstly emphasizes the need for data collection from various sources such as customers, suppliers and process performance. Additionally, it highlights the need for data analysis and visualization tools, that provide the basis for timely and value-adding insights, essential for driving continuous improvement effectively (Singh & Singh, 2015).
3. **Process oriented approach**
Resources and activities should be managed as a process. Continuous Improvement requires the identification, understanding and management of systems of inter-related processes, which is an essential principle in the achievement of operational excellence (Imai, 1986; Singh & Singh, 2015).
4. **Customer-driven organization**
A deep understanding of customers' needs is essential in the waste identification process. The company's goal is always to meet customer requirements and expectations, distinguishing between value-added tasks that contribute to customer satisfaction and non-value-added tasks that should be continuously minimized (Singh et al., 2009).
5. **Process standardization**
Continuous improvement focuses in creating small, lasting improvements that should be built upon one another leading to significant continuous change.
Without standards, no improvement can be achieved, because standardization is the very foundation that allows for the small continuous improvements to accumulate and significantly contribute to organizational performance (Imai, 1986).
Standards importance revolves around 3 main drivers: 1) Individual authorization and responsibility 2) Knowledge acumen, ensuring best practices are passed on between workers so that optimum performance can be achieved and 3) Discipline (Singh & Singh, 2015).
To support work standardization, the PDCA problem solving methodology allows for a never-ending cycle of multiple process improvement and standardization and therefore ensuring that every improvement project is complemented by and adds upon previous improvement projects (Singh & Singh, 2015).

The Kaizen process-oriented approach is based on Deming's "plan-do-check-act" (PDCA) cycle methodology: 1) Plan phase- the current situation is studied, and improvement changes should be planned and analysed. 2) Do phase- the improvement plan should be executed in

controlled circumstances in order to collect data on project's actual performance. 3) Check phase- the results of the Do phase should be analysed and the project should be adapted or improved upon, increasing the projects probability of success. 4) Action phase- it's the phase where the project is fully put to action, and improvements should be standardized as the new status quo (Bond, 1999; Singh & Singh, 2015).

3 Problem Description

This chapter starts with the description of the produced cork stopper families within the unit as well as the targeted product range and manufacturing processes.

Secondly, a capacity study was conducted on the agglomerate cork stopper section, in order to determine the production bottleneck as well as other capacity restraints.

Complementing the bottleneck analysis, a VSM was done of the section, including details such as average time spent in inventory in every buffer as well as the overall production lead time and processing time.

Finally, the VSM and capacity studies served as the foundation for the identification of improvement opportunities within the section and the development of the proposed solution plan that is described in detail in Chapter 4.

3.1 Technical and Agglomerate Cork Stopper Families

SOCORI Industrial Unit manufactures a wide variety of cork stoppers that can be divided into 3 families, the price range per family was gathered in SOCORI Industrial Unit's SAP ERP.

The first family, Natural Cork Stoppers, differs from the other two the fact that its raw material is a sheet of cork that will then be drilled, treated, and machined. Its price range in SOCORI Industrial Unit goes from 100 to 800€ per 1000 cork stoppers.

The second family, Agglomerate Cork Stoppers, utilizes the drilled cork sheet and defective cork stoppers as its raw material. This raw material is shredded, sorted according to its density and grain size and then treated in order to reduce the overall levels of TCA within the grain. The granulated cork will be mixed with glue and moulded or extruded in different sizes and with different grain and glue mixes. After being machined with the final shape, this family of cork stoppers will be chemically washed. Its price range can go from 20 to 140€ per 1000 cork stoppers.

The third family, Technical Cork Stoppers, is a ramification on the second family, but after the granulated cork and glue is moulded or extruded and machined, one or two disks of cork will be glued in one or both sides of the cork stopper, then it's machined again and chemically washed. Its price ranges from 40 to 200€ per 1000 cork stoppers.

The manufacturing of the natural cork stopper process is highly dependent on the cork batches bought yearly making its gradings unpredictable, consequently, its production requires to be inherently done through a push production model and a late stage CODP. For this reason, the natural cork stopper was not studied in this work that aims primarily in aiding the transition of the Push production approach to a more market-oriented Pull approach. With more linear and predictable product mixes and capacity allocations, the Agglomerate and Technical Cork Stopper families were the focus of this study.

3.1.1 Agglomerate cork stopper products

For the agglomerate cork stoppers, a significant variety of products is available. Agglomerate cork stoppers differ among themselves the type of grain, amount of TCA within the grain, grain-glue mix, cork stopper size and cork stopper shape. Visually, the difference between micro agglomerate cork stoppers and regular agglomerate cork stoppers can be seen in Figure 6 and Figure 7.



Figure 6: RN Granulated Cork Stoppers



Figure 7: RCT Granulated Cork Stoppers

Within the micro agglomerated cork stoppers, which includes the Delta, Rubi, Rubi Cristal, SPI, New, Nano and DXL cork stopper products. All these products use the smaller grain RN, with an exception of the SPI product that uses a RA-AD mix, the two heavier types of the small and large grain.

Delta, Rubi, and Rubi Cristal differ among themselves only the amount of TCA in the RN grain, Delta uses regular RN granulate, Rubi uses the same granulate but the grain is confirmed via quality test that a lower amount of TCA is present, and Cristal includes RN granulate that passes through the new Cristal TCA treatment process. SPI cork stoppers are very similar to the previous three but the used granulate is a mix of RA and AD granulate, RA being a bigger sized grain than the AD, but both being the denser kind of grain, thereby making a heavier, less expensive cork product, see Table 1.

The NEW cork stoppers are the smallest of the range, using regular RN grain. The NANO and DXL cork stoppers use the same granulate, RN, but the RN-glue mix is different than the one verified in Delta, Rubi, and Cristal. DXL cork stoppers are bigger than the NANO cork stoppers, see Table 1.

For sparkling wine, only one product within the range is composed of the smaller grain, RN, which is the JUMP product, which is bigger than the regular Delta, Rubi and Cristal, but also uses a different grain-glue mix, see Table 1.

Table 1: Micro agglomerate cork stopper families

Family	Delta	Rubi	Rubi Cristal	SPI
Grain	RN	RN Plus	RN Cristal	RA + AD
Size	B (medium)	B (medium)	B (medium)	B (medium)
Family	New	Nano	DXL	JUMP
Grain	RN	RN*	RN*	RN*
Size	A (very small)	B (medium)	C (big)	C (big)

The bigger sized grain, RCT and RA, is used in agglomerated cork stoppers for the product family Cidra, for cider bottles.

For the elaboration of a Pareto Diagram, data was collected on the number of cork stoppers sold within each product for the agglomerate cork stopper family in the year 2023, see Figure 8.

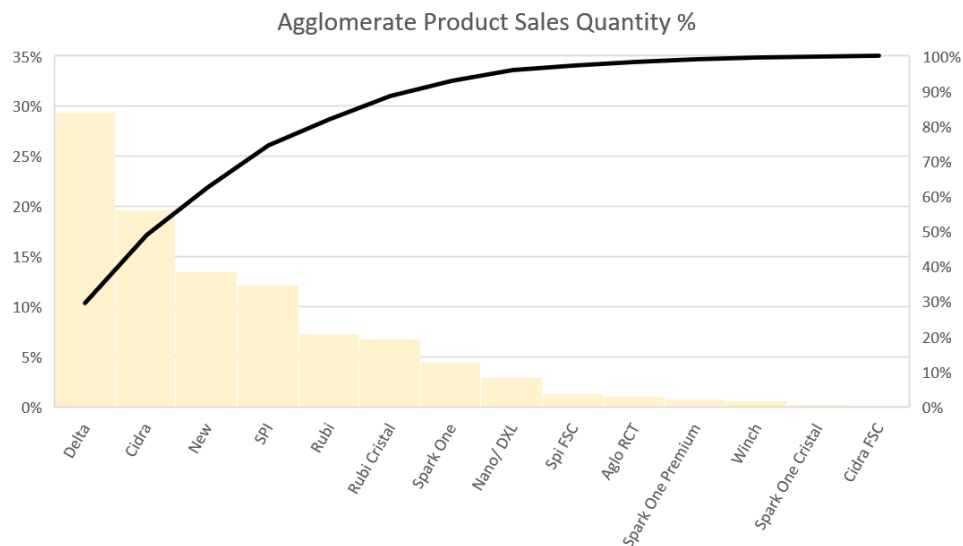


Figure 8: Pareto Diagram on Agglomerate Cork Stopper Sales Volume in 2023

3.1.2 Technical cork stopper products

Within the technical cork stoppers, the most popular products are the CH 1D, CH 2D, Fusion and Sigma. CH 1D and CH 2D are applied in sparkling wine, they usually include RCT grain, which is the biggest in size, as well as 1 or 2 natural cork disks, respectively, in only 1 side. The Fusion and Sigma are commonly applied in still wine, the first is composed by the smaller grain RN and the second by bigger grain RCT, they can have 1 or 2 disks but applied to both sides, this happens because still wine bottling machines are typically blind regarding the orientation of the cork stopper. The different cork stopper solutions can be seen in Figure 9, Figure 10, Figure 11 and Figure 12.



Figure 9: Fusion cork stopper



Figure 10: Sigma cork stopper



Figure 11: CH 1D cork stopper



Figure 12: CH 2D cork stopper

Data was also collected on the number of cork stoppers sold within each product for the technical cork stopper family, elaborating the Pareto Diagram seen in Figure 13.

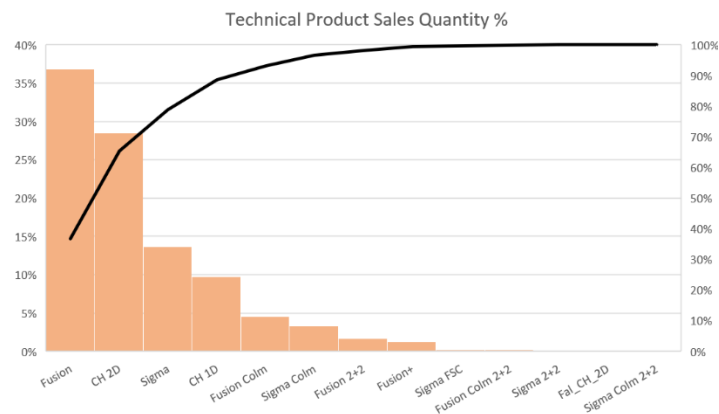


Figure 13: Pareto Diagram on Technical Cork Stopper Sales Volume in 2023

A comparison of both cork stopper family's sales volume and value contribution can be seen in Figure 14.

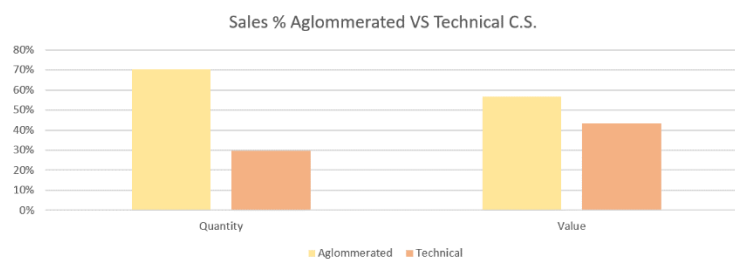


Figure 14: Agglomerate and Technical Cork Stopper Sales Volume and Value % in 2023

3.2 Agglomerate Cork Stopper Manufacturing Process

The Agglomerate Cork Stopper manufacturing process follows the production steps described in Figure 15.



Figure 15: Agglomerate Cork Stopper Manufacturing steps

Firstly, the waste from drilled cork sheets (from the natural cork stopper manufacturing) and defective natural cork stoppers are shredded and sorted according to its density and size, see Table 2.

Table 2: SOCORI Industrial Unit different types of grain

	RCT	RA	RN	AD
Grain Size	large	large	small	small
Density	light	heavy	light	heavy

The difference between lighter and heavier grain is the origin of the cork, heavier cork has a darker tone and a greater amount of TCA, this tone comes from the outer layer of the cork sheet, which is thicker when closer to the ground, therefore, heavier grain is considered less desirable and is, consequently, cheaper.

After sorting, the cork grain undergoes treatment in one of three machine types: Vortex, Sterilizer, or Cristal. The primary goal of this treatment is to eliminate the highest proportion of TCA within the grain mix. The Sterilizer, being the oldest process, is consequently less effective. The Vortex, a newer process, is more effective than the Sterilizer. Meanwhile, the Cristal treatment, anticipated to be fully operational by June 2024, represents the newest process. Products treated with Cristal are sold at a premium due to their guarantee of TCA untraceability.

After each cork grain is sorted and treated, it is stored in either silos or big bags, silos pour directly into the moulding and extruding machines, while big bags are manually loaded into hoppers that feed each machine.

The next phase in the manufacturing process is the moulding or extrusion of the cork stopper bodies, which are cylinder shaped, here the grain is loaded either exclusively from silos or from both silos and hoppers, depending on the machine, as some machines are only loaded through silos, not allowing the mix of different grains. As previously mentioned, some bodies include a mixture of up to 2 grain types and can also differ on the quantities and types of glue within the glue-grain mix. After being moulded or extruded, the bodies are loaded into carts and left in stock to stabilize their volume and density, for a minimum period of 24-36 hours depending on the cork stopper body size.

After stabilizing, the cork stopper body is machined with its final geometry and dimensions, machining the cork stopper bodies diameter and length, as well as adding a bevel, which may or may not be added, depending on the product's market standards and clients' orders. After being machined, the cork stopper is stored in carts.

The washing of the agglomerate cork stopper is an optional step, and its choice is mainly dependant on the product, for example, Delta products typically are always washed, while Cidra products are never washed, depending on market standards and clients' orders. When opted, the washing type of the cork stopper can also be picked by the customer.

The last step in the Agglomerate Cork Stopper Section is electronic selection, where defects are detected and the cork stopper will either go on to the next steps according to the final product's specifications or, due to the number of defects, either be sold as is or rectified to a smaller dimension.

After the cork stoppers are electronically picked, samples are taken from the cork stopper batches produced, where density, TCA level, humidity and other problems are identified, if the C.S. does not pass the tests, corrective measures are introduced to the C.S. before they continue the production process.

After the electronic selection and quality tests are performed and passed, the agglomerate cork stopper will then follow 1 of 2 possible paths, the first including being directly shipped to BOURASSÉ facility in Tosse, France, where the cork stopper's final details are added, namely, marking and coating; and the second path includes sending the cork stopper to the marking and coating sector in SOCORI (MTE sector), where products can then be directly shipped to the final client.

3.3 Technical Cork Stopper Manufacturing Process

The Technical Cork Stopper manufacturing process follows the production steps described in Figure 16.

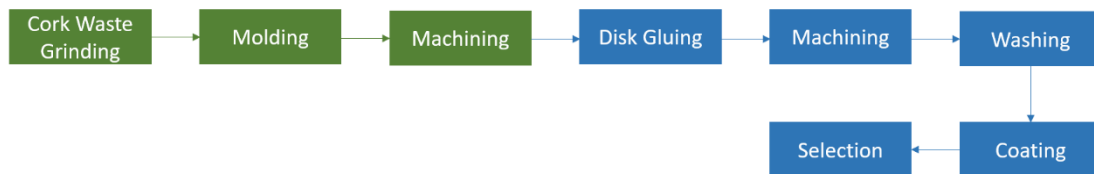


Figure 16: Technical Cork Stopper Manufacturing steps

For the technical cork stopper processing, after the cork stopper body is moulded/extruded in the agglomerate cork stopper section. The machining of the cork stopper body is also done in the agglomerate cork stopper sector, differing only that lines that produce cork stopper bodies never add a bevel to the body, but also in the fact that CH_1D and CH_2D product ranges are weighted after they are rectified.

After the cork stopper bodies are moulded and machined, samples are also taken from the cork stopper batches, performing the same tests and possible corrective measures as the agglomerate cork stoppers.

The fourth step in the technical cork stopper manufacturing process is gluing disks to the cork stopper, in this step, either 1 or 2 disks are glued in both sides, typically for still wines, or 1 or 2 disks are glued in only 1 side, commonly seen in sparkling wine corks. After the disks are glued, the cork stoppers need to be stored for at least 24 hours to stabilize.

After the disks are glued and have stabilized, the machining of the cork stopper with its final dimension is done.

Technical cork stoppers can then either be washed and/or coated, after which the cork stopper body is visually and chemically inspected.

Finally, the technical cork stopper will follow 1 of the same 2 possible paths for the agglomerate cork stoppers, namely, being shipped to Tosse, France, for the final details, or having them added in the marking and coating sector in SOCORI to be shipped directly to the final client.

3.4 Capacity Study

3.4.1 Moulding/Extrusion Step

Both technical and agglomerate C.S. go through this process, therefore its capacity needs to be able to meet demand for all included product families described before. This process step occurs in 3 shifts, during the 5 weekdays (24/5).

In 2024 there is a focus on maximizing the utilization of the moulding process, minimizing the utilization of the extrusion process, this choice was based on two main reasons:

1. The current molding machines are more efficient than the extrusion machines, reducing manufacturing processing costs.
2. The molding process capacity is sufficient to meet the majority of demand, with some exceptions requiring the utilization of the extrusion process for part of the cider production (0.01% of total predicted demand) and resorting to third party producers to supply part of the predicted demand.

For the capacity study, the moulding machines were primarily focused since they include 94% of predicted production in 2024 and after February 2024 all extrusion machines were stopped.

Regarding the theoretical capacity of the moulding machines, considering the current cadence of production as well as the predicted available time, data was gathered in the shop floor about the number of bodies per mould in each machine and the rotation time between the moulds. The number of bodies per mould is constant for each machine, remaining constant throughout the year. Rotation time between the moulding of each mould was registered in the machine's controlling system, however, a sample of 20 cycle times were timed per machine in the shop floor, to further investigate on its accuracy and standard deviation, see Table 3.

Table 3: Hourly Theoretical Capacity of each moulding machine

	1	2	3.1	3.2	4	5	6	7.1	7.2.
Bodies / Mould	34	34	38	38	54	27	100	38	38
Rotation time	5.9s	6.0s	10.4s	10.4s	8.6s	8.0s	10.1s	8.8s	8.8s
Std. dev	0.12s	0.12s	0.19s	0.19s	0.15s	0.21s	0.13s	0.14s	0.14s
Hourly Capacity	20 746	20 400	13 154	13 154	22 605	12 150	35 644	15 545	15 545

As it can be seen in Table 3, the moulding machines differ regarding the number of bodies per mould, which depends not only in machine model, but also the body's diameter. Moulding machines also differ regarding the rotation time between moulds, which heavily depends on the machine model, but also on the C.S. body's dimensions and overall recipe (grain and glue), as the recipe can vary, these capacities may vary depending on the glue-cork mix used.

Each moulding machine's predicted available time includes maintenance that happens once every shift, as well as the weekly setup that takes approximately 6 hours to complete. The estimation of predicted maintenance that happens once every shift was based on operator's experience. Based on these values, weekly capacity was estimated, see Table 4.

Table 4: Weekly available time and theoretical capacity of each moulding machine

	1	2	3.1	3.2	4	5	6	7.1	7.2.
Available Time (hours)	109	109	109	109	99	99	99	114	114
Weekly Capacity (k C.S.)	2 261	2 224	1 434	1 434	2 238	1 203	3 529	1 772	1 772

The average weekly production in 2024 of each machine was retrieved from the MES database. MES is an information management system that connects to each machine and other equipment, controlling processes inputs and outputs, as well as tracing stock movements of all produced and consumed components, exchanging information in real time with the ERP system.

Considering machines very long setup time, they typically run during the 5 week days in 3 shifts (24/5), to calculate the average weekly capacity, an average throughout the year 2024 was used, taking into account only weeks where each machine has produced, resulting in the values seen in Table 5.

Table 5: Moulding machines average weekly and hourly capacity in 2024

	1	2	3.1	3.2	4	5	6	7.1	7.2.
Weekly Cap.	950	1 076	713	764	1 291	761	2 529	930	942
Hourly Cap.	7.9	9.0	5.9	6.4	10.8	6.3	21.1	7.8	7.9

The average weekly capacity in 2024 was significantly lower than the theoretical capacity. This discrepancy can be attributed to several factors: unexpected breakdowns, holidays, and planned stoppages due to fluctuating demand and inventory levels. The real weekly capacity of the moulding machines is 9,956 k C.S. bodies, resulting in an hourly capacity (divided by 5x 24h) of 83.0 k C.S. bodies.

3.4.2 Machining Step

Similarly to the previous step, both technical and agglomerate C.S. go through this process, which also occurs in 3 shifts (24/5).

The machining section is divided into 14 machining lines, each line can include machines in 4 categories:

1. *Ponçadeira* – responsible for machining the outer diameter of the cork stopper to the desired diameter
2. *Topejadeira* – responsible for machining the top and bottom of the cork stopper to the desired length
3. *Chanfradeira* – responsible for chamfering the cork stopper
4. *Ponderal* – weights the cork stopper at the end of the line

Not all machining lines include the same machines, nor the same number of each machine, although cork stoppers always go through the same order or processes: *ponçadeira* to *topejadeira* to *chanfradeira* and *ponderal* at the end.

Calculating the machining process capacity passed through calculating each of the machining lines bottleneck. To do so, all the machines within each of the lines were measured in terms of time to produce 30 cork stoppers.

The number of machines within each machining line can be seen in Table 6.

Table 6: Number of machines within each machining line

	Ponçadeira	Topejadeira	Chanfradeira	Ponderal		Ponçadeira	Topejadeira	Chanfradeira	Ponderal
Linha Ret 01	4	2			Linha Ret 09	6	2	2	
Linha Ret 02	4	2			Linha Ret 10	4	2		
Linha Ret 03	2	1	1		Linha Ret 11	4	2		
Linha Ret 04	4	2			Linha Ret 12	2	2		
Linha Ret 05	4	2			Linha Ret 13		2		
Linha Ret 06	4	2			Linha Ret 14	4	2		
Linha Ret 07	6	2	2		CH 01.1			2	
Linha Ret 08	6	2	2		TOP 03.1		1		

Regarding the machining process theoretical capacity, 5 samples were taken for the production time of 30 C.S. in each of the 92 machines, resulting in the average times seen in Table 7. Machining lines that were not working during any of the samples was estimated with an average of each machine type.

Table 7: Production time for 30 C.S. for each machine within each machining line

Linhas	CH 01.1	CH 02.1	Linha Ret 01	Linha Ret 02	Linha Ret 03	Linha Ret 04	Linha Ret 05	Linha Ret 06
PON .1 E/A	-	-	34,53	37,51	37,51	26,51	20,15	19,24
PON .1 D/B	-	-	26,02	37,51	37,51	60,87	19,04	21,99
PON .2 E/A	-	-	42,27	37,51	-	27,03	19,24	14,73
PON .2 D/B	-	-	61,78	37,51	-	53,57	17,85	16,10
PON .3 E/A	-	-	-	-	-	-	-	-
PON .3 D/B	-	-	-	-	-	-	-	-
TOP .1	-	-	14,01	25,42	-	12,71	11,79	11,47
TOP .2	-	-	10,59	15,39	13,50	10,21	9,40	11,43
CH .1	8,67	-	-	-	9,40	-	-	-
CH .2	9,40	-	-	-	-	-	-	-
PONDERAL	-	-	-	-	-	-	-	-
Linha Ret 07	Linha Ret 08	Linha Ret 09	Linha Ret 10	Linha Ret 11	Linha Ret 12	Linha Ret 13	Linha Ret 14	TOP 03.1
33,01	28,60	40,95	40,20	38,27	37,51	-	37,51	-
61,18	27,22	41,32	27,37	14,32	37,51	-	37,51	-
23,93	57,65	25,34	26,68	29,13	-	-	37,51	-
21,45	48,09	24,46	36,11	49,44	-	-	37,51	-
39,31	56,60	27,85	-	-	-	-	-	-
19,45	29,05	44,12	-	-	-	-	-	-
10,64	9,57	10,62	14,83	13,57	12,71	11,25	12,71	12,71
10,95	10,45	7,75	14,65	14,24	12,71	11,18	12,71	-
9,86	9,12	9,55	-	-	-	-	-	-
8,65	9,50	10,48	-	-	-	-	-	-
-	-	-	-	-	-	30,37	-	-

After calculating the bottleneck for each line, the theoretical cadence of each line was calculated as seen in Table 8, resulting in an hourly capacity of 233 K. cork stoppers.

Table 8: Machining lines theoretical hourly capacity (in thousand cork stoppers)

Line	CH 1.1	CH 2.1	Line 1	Line 2	Line 3	Line 4	Line 5	Line 6	Line 7
Capacity	23.9	-	11.6	11.3	5.8	11.9	20.6	18.9	20.0
Line	Line 8	Line 9	Line 10	Line 11	Line 12	Line 13	Line 14	Top 3.1	
Capacity	17.5	20.3	13.7	15.5	5.8	16.0	11.5	8.5	

When measuring timings for each machines theoretical cadence, a problem of significant down time was detected in all machines, but more significantly in the *ponçadeira* machines, which was the bottleneck for most machining lines regarding theoretical capacity.

Since this section usually includes many stoppages between processed lots due to having to wait for the previous processes, determining its real capacity passed through analysing the hourly production of the line in 2024, selecting time blocks where production followed a pattern and from this pattern estimate a real production capacity, the results on hourly production are seen in Table 9. Since line 12 did not produce in 2024, its theoretical capacity was not used for the calculation of the real capacity of the machining process, which resulted in 107 k. cork stopper production hourly capacity.

Table 9: Machining Section's real hourly capacity

Line 1	Line 2	Line 3	Line 4	Line 5	Line 6	Line 7
6 396	4 900	3 979	8 333	6 208	11 806	14 433
Line 8	Line 9	Line 10	Line 11	Line 12	Line 13	Line 14
13 500	8 597	4 825	6 615	-	11 500	5 808

SOCORI Industrial Unit's production approach includes standard routes for each cork stopper body, however, not all machining lines are compatible with all products, see Table 10, this happens for 2 reasons:

1. Some items require a chamfer, and not all machining lines include a *chanfradeira* machine.
2. Products are divided into 3 groups: Slim, Semi and Thick products, machines need to be compatible with the cork stopper body because of the feeding of machines.

Table 10: Machine- product capacity

Machines	Linha Ret 01	Linha Ret 02	Linha Ret 03	Linha Ret 04	Linha Ret 05	Linha Ret 06	Linha Ret 07	Linha Ret 08
Slim	1		1	1			1	1
Semi	1		1	1	1	1		
Thick		1						
Chamfer		1	1				1	1
Machines	Linha Ret 09	Linha Ret 10	Linha Ret 11	Linha Ret 12	Linha Ret 13	Linha Ret 14	CH 01.1	TOP 03.1
Slim	1						1	1
Semi							1	1
Thick		1	1	1	1	1		
Chamfer	1						1	1

There are 11 different moulded bodies, each with a different standard item to be produced, the list of all products and related cork stopper bodies can be seen in Table 11 as well as it's respective group, which is used to allocate its production in the machining sector.

Table 11: Moulded Body - Machining Group Compatibility

1 - Delta	1 - Cristal	1 - SPI
CORPOS MOLD 52X26 RN	CORPOS MOLD 52X26 RN CRISTAL	CORPOS MOLD 52X26 RA AD
2- Jump	2 – Jump Cristal	2 - DXL
CORPOS MOLD 52X32 RN JUMP	CORPOS MOLD 52X32 RN CRISTAL	CORPOS MOLD 52X32 RN DXL
3- New	3 – Fusion	3 - Nano
CORPOS MOLD 35X22 RN	CORPOS MOLD 42X26 RN	CORPOS MOLD 42X26 RN NANO
4- CH_2D	4 - Cidra	
CORPOS MOLD 46X35 RCT	CORPOS MOLD 50X32 RCT	

The allocation of each group to a machining line in 2024 can be seen in Table 12.

Table 12: Machining line - product group allocation 2024

Line 1	Line 2	Line 3	Line 4	Line 5	Line 6	Line 7
1/3	4	1/3	3	3	3	1
Line 8	Line 9	Line 10	Line 11	Line 12	Line 13	Line 14
1	1	4	4	-	4	2

With lines 7,8 and 9 being allocated to the production of group 1, and assuming lines 1 and 3 use half their capacity for group 1 and 3, the machining capacity by group can be seen in Table 13.

Table 13: Machining line capacity by group

Group 1	Group 2	Group 3	Group 4
41 718	5 808	31 535	27 840

3.4.3 Washing Step

Unlike both previous processes, not all cork stoppers go through the washing process in the agglomerate cork stopper section, namely, only the families Delta, SPI and Cristal are always washed, the NEW, NANO, DXL and technical cork stopper bodies only go through this process when burr is present in the cork stopper lot after machining, in a process called *despoeiramento*, in order to fix this burr.

There are only 3 similar cork stopper washing machines, their capacity is constant in terms of volume, but considering there are multiple different cork stopper sizes, the quantity produced in each batch can vary between 30 and 50k cork stoppers per batch.

Each batch requires about 20 minutes to load the cork stoppers, replenish chemicals and interacting with MES, the washing time depends on the cork stopper washing type, the *despoeiramento* process takes 23 minutes, the PX, PXR and ECO washing types take 35, 100 and 40 minutes, respectively.

Considering 3 machines, the hourly capacity for *despoeiramento* is 152 k C.S. and the weighted average of the remaining washing processes is 95 k C.S.. Overall, the estimation for this processes bottleneck was the weighted average of every process including *despoeiramento* and regular washes, resulting in a real cadence estimation of 107k C.S.

3.4.4 Electronic Selection Step

There are currently 6 electronic selection lines, each with 2 electronic selection machines. Each electronic selection machine is set to the constant cadence of 9k C.S./hour. The theoretical capacity of the electronic selection process is 108k C.S./hour.

3.4.5 Bottleneck analysis

Considering all previously stated capacities, the moulding process was revealed to be the section's bottleneck, however, for better comparison, the capacities of each process need to be corrected according to the proportion of items that are processed in each step, because not all products pass through the steps of washing and electronic selection. The proportion of items that are processed in each section as well as the capacity and the proportion correction of capacity is stated in Table 14, the section's bottleneck is the moulding process, meaning that, unless any of the other processes are working at a lower rate than its maximum of 86k C.S./hour due to unpredicted breakdowns, the moulding phases will set the section's production cadence.

Table 14: Levelled Agglomerate Cork Stopper Section Processes Capacity considering resource allocation

Section	Moulding	Machining	Washing	Electronic selection
% Processed	100%	100%	78%	66%
Capacity	83	107	107	108
Levelled capacity	83	107	137	164

Analysing the weekly production in MES, the average hourly production in 2024 was 79.5k C.S., which makes sense considering that it is not higher than the predicted 83, which considered all 7 moulding machines working 24/5, which was not verified due to unpredicted machine breakdowns or planned stoppages.

Considering the moulded cork stopper body – machine compatibility mentioned in Chapter 3.4.2: Machining Step, a bottleneck analysis was made considering only the moulding

and machining step, since all other steps are above capacity. To do so, both moulding machines were also grouped into the 4 groups as seen in Table 15, according to the planned production in 2024.

Table 15: Moulding Machine- Material Group Allocation

	M. 1	M. 2	M. 3.1	M. 3.2	M. 4	M. 5	M. 6	M. 7.1	M. 7.2
Group	G1	G3	G3	G3	G1	G2	G1	G4	G4
Capacity	7.9	9.0	5.9	6.4	10.8	6.3	21.1	7.8	7.9

Considering both the moulding production capacity by group (see Table 5 and Table 15) and the machining section's capacity by group seen in Table 13, the resulting capacities can be seen in Table 16.

Table 16: Bottleneck analysis by product group (hourly capacity)

	G1	G2	G3	G4
Molding Cap.	39.8	6.3	21.3	15.6
Machining Cap.	41.7	5.8	31.5	27.8
Margin	105%	92%	148%	178%

From this analysis, even though the moulding section is typically the bottleneck, this is not the case for group 2 products: Jump, Jump Cristal and DXL, meaning that in order to avoid stock build up, machining lines of other groups need to be used, namely group 4, which is compatible with thick bodies.

Another significant remark is that even though the machining sector is not the bottleneck, it's margin in comparison to the machining sector is not very high in group 1, where there is only an 5% gap in production relative to the moulding sector's capacity, which can be concerning considering that none other lines are capable of doing this product, since they are either not compatible with thin bodies or do not have a *chanfradeira* machine. Meaning that there is risk of stock build up in case of any machining line lowering its production capacity or the moulding machines increasing their capacity.

3.5 Agglomerate Section As Is Planning Model

Cork stopper manufacturing as a business is characterized for having a production mix with sales being very influenced by seasonality. In order to deal with this seasonality, companies either opt for building stock in advance in order to meet peak demand, resulting in a MTS approach (see previous chapter MTS and MTO Manufacturing) or produce in real time, in a MTO approach.

BOURASSÉ group's approach leans more towards MTS, keeping stock close to BOURASSÉ's biggest market, France, BOURASSÉ Sales distribution by country can be seen in Figure 17. Although stock is only kept in France, this is only the case for standard items, which satisfy the majority of sales volume, non-standard items, such as items with a different size, washing or with a bevel are produced in a MTO approach, having higher lead times and consequently higher time to market.

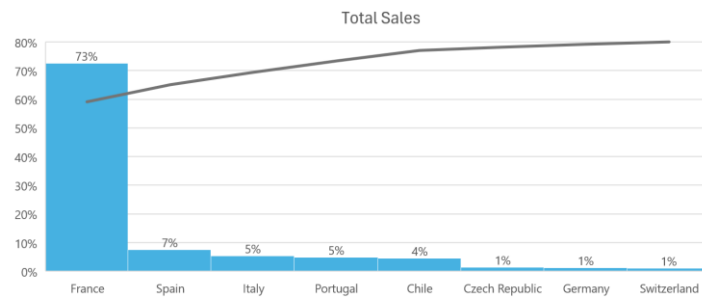


Figure 17: BOURASSÉ Group client's geographic distribution

An important note regarding the BOURASSÉ Group's manufacturing approach is that standard items are customized near the client, in France or Chile, where stock is kept without final customization at these stock points. Final customization, such as adding the customer's logo and coating the cork stopper, is performed only when a customer order is placed. This makes the previously described MTS (Make-to-Stock) approach closer to an ATO (Assemble-to-Order) approach.

The SOCORI Industrial Unit manufactures its products without keeping stock at the facility, as their stock point in France is responsible for maintaining inventory levels defined by the yearly forecast. A similar approach is taken for the group's headquarters in Chile, known as BOURASSÉ Chile. Orders sent to these locations are considered MTS and do not undergo final customization at SOCORI. Consequently, delivery lead time to the client includes only the final customization in France or Chile and delivery to the end customer, requiring SOCORI to consistently restock their inventory levels throughout the year.

Orders that require final customization in SOCORI typically go directly to the final client, being considered MTO production. For this MTO production, 2 approaches are taken in SOCORI:

- **Standard approach:** As mentioned before, SOCORI manages its production through standard routes regarding each moulded cork stopper body, this production is done in a Push approach with a CODP at the electronic selection process, after which the production is directed either to MTS in France/Chile or to the MTE (marking and coating) sector in SOCORI. These MTO orders are given higher priority than the MTS orders, considering that the delivery lead time will include the final customization in SOCORI as well as its delivery to the client.
- **Non-standard approach:** Contrarily to the first approach, not all products follow the standard production route, a standard Delta product can have a different washing than the standard PX. Items can have a chamfer or even be required to be a slightly different size than the standard route, providing the final client a wider variety of choice. These orders have an earlier CODP, typically at the machining section or washing section, meaning that production lead time for these items include not only the final customization in SOCORI, but also other processes upstream in the manufacturing process. These items are given then highest priority regarding manufacturing.

This mixed MTS and MTO approach has several benefits such as the levelling of production, utilizing machines more efficiently as well as human labour, the ability to better plan out production, but also the fast delivery times to all countries served by the stock point in France regarding standard items. The different treatment of MTO orders provides the company more versatility regarding product variety, without the drawbacks of significantly increasing stock levels.

As stated before, the Agglomerated and Technical Cork Stoppers production capacity bottleneck is the moulding process, therefore, the levelling of production goes through a higher up planning of this process by the supply chain department, which decide what products to make in each moulding machine, when to stop it, setup timings and overtime requirements, such as extra shifts in the weekends.

After the moulding process, the electronic selection, the washing process and the machining section work below maximum capacity, with a Push production approach, supply chain gives directions to the agglomerate and technical cork stopper sections on how much to produce of each item and the information is passed to the shift leaders and line workers.

3.6 Agglomerate Section Value Stream Map

For the Value Stream Map, several assumptions were made, namely:

1. The amount of cork stoppers considered for cycle times were 40 thousand, assuming in the washing step that this corresponds to 1 car, which is a simplification considering different products are carried in different quantities inside each car, depending on their size.
2. Inventory quantities were only tracked for typical products that are sold to the customer, this excludes 2 types of C.S. that result from the electronic selection and weighting machine:
 1. Items with a code starting by RT DEF_MICRO or RT DEF_AGL_RCT, which are sold to the market as defects, without the possibility of being internally reworked, naturally, these are produced at a very low cadence and therefore stay longer in inventory than the average cork stopper. These items are only present at the stock after electronic selection, see Figure 18.
 2. Items with a REP at the end of their code, which stands for *repassé*, which are all cork stoppers with a quality level that is not acceptable by the final client as is, but its defects allow the rework of the cork stopper. These items can be present in 2 inventories, stock after picking as well as the pre-machining stock, see Figure 18.

WIP Inventories position themselves inside the production chain as stated in Figure 18.

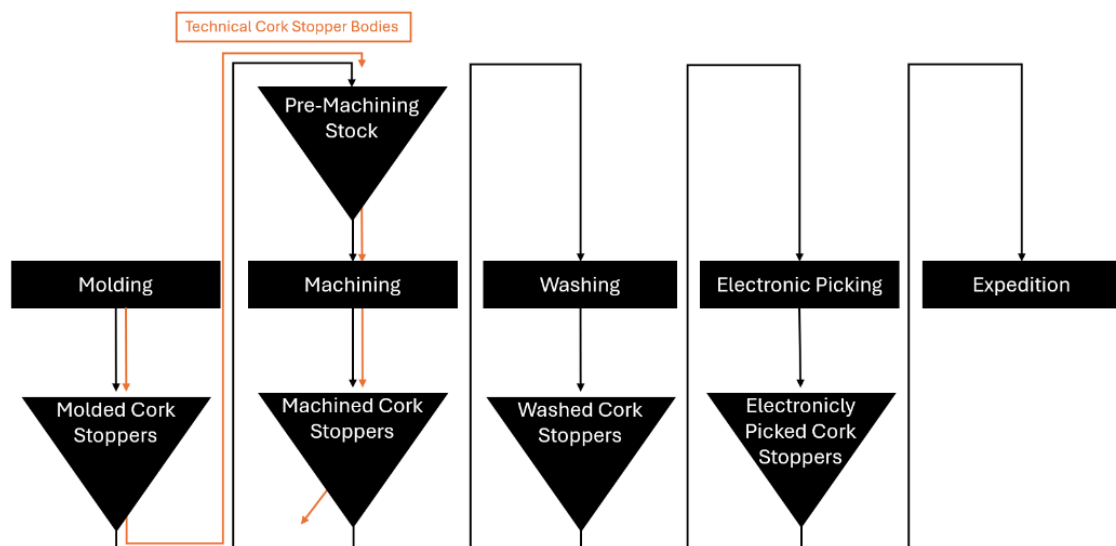


Figure 18: WIP Inventories flowchart

Considering some production policy changes that differ from approaches taken in previous years, such as the new Cristal process, the production stoppage of the extrusion process as well as the fact that some products were now opted to be subcontracted, inventory levels, similarly to production capacities were considered regarding this year's performance, considering the average inventory levels of the current year 2024, covering production between January to May.

The average hourly production in 2024, once again resorting to the MES database was 79 452 C.S./hour, this cadence was used for the calculation of the time period in inventory of each product route. The inventory time was calculated considering the different production rates in each step, following Equation 1.

Equation 1: Inventory time at each step

$$Inventory\ Time_p = \frac{INV_p}{PRate * PQuant_p}$$

INV_p : Inventory level after process b; $PRate$: Production Rate (average hourly production); $PQuant_p$: Proportion of overall production that goes through step p.

Additional information was gathered for the setup times of each step's changeover.

- For the molding machine this happens in every cork-glue mix change.
- For the machining step, every time a machining line changes from a certain diameter or length to another or ceases/starts creating a bevel in the cork stopper.
- The washing step was considered to have no change over time, as production is done car by car and no time is added from changing from one batch of cars to another.
- For the electronic selection step, every time the batch has a different coloration (washing treatment or cork stopper glue-grain mix used) or different geometry.

However, no details were added regarding the grinding operation and cork grain treatment's stocks and buffers that are kept in both silos and/or big bags, because at this step some grain is sold to clients and bought from suppliers according to production needs, the production is pushed to the moulding step or sold, but also because this step will change dramatically in terms of production mix and capacity allocation in each machine because of the new Cristal process that is predicted to be fully operational by June 2024.

All data described above culminated in the VSM seen in Figure 19.

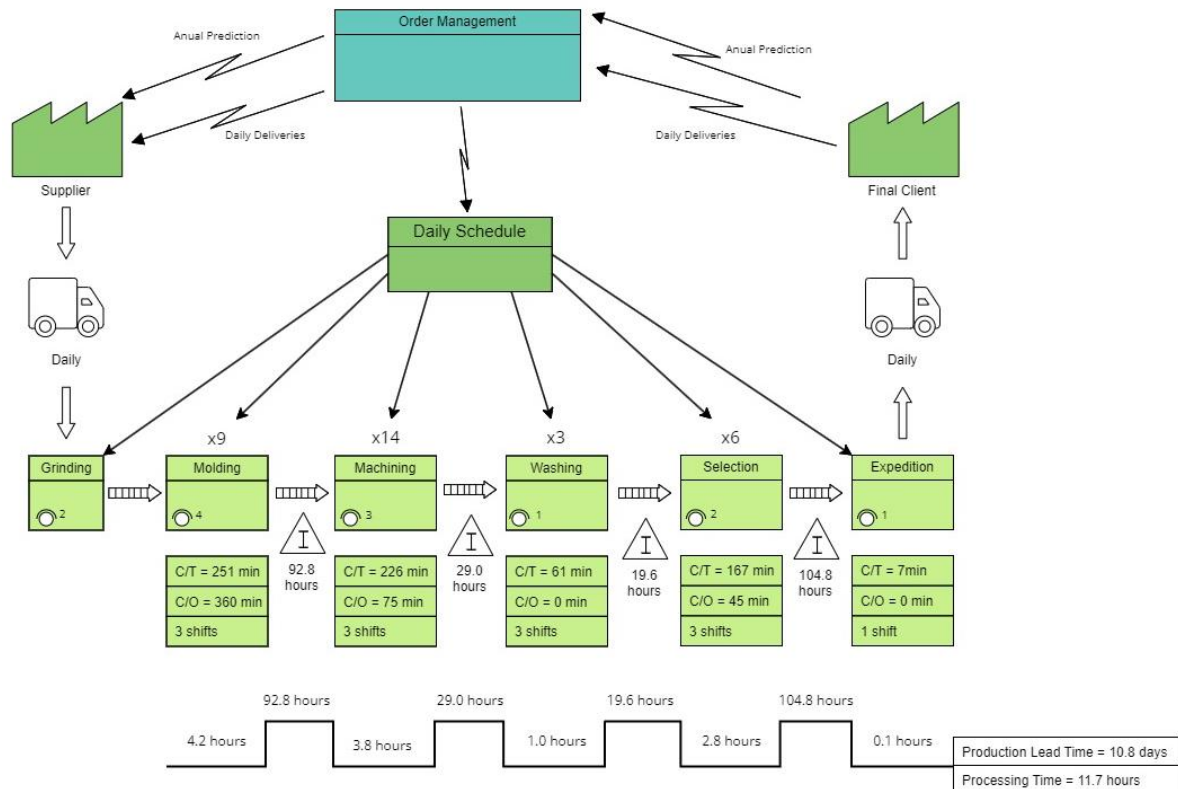


Figure 19: Agglomerate Cork Stopper VSM

Regarding the production lead time of 10.4 days, it should be noted that inventory waiting times are not the same for each product, some products wait less than others in inventory depending on the priority of the item, which depends on delivery dates and quantities.

Another note on lead time is important for technical cork stoppers, as cork stopper bodies do not go through the selection nor expedition processes, but instead needs to go through the gluing, machining and other treatments.

Regarding the order fulfilment lead time, it will only include processes after the CODP, meaning that non-standard items may include a production lead time of up to 6.7 days + time to make final customization, if it's a standard MTO item the only time spent in inventory after selection and expedition will be included in the lead time, resulting in 4.4 days + time to customize.

Moulded Cork Stopper Bodies

After de moulding step, products spend on average 92.8 hours before proceeding to the next step. As explained in Figure 18, this inventory is divided into 2 inventories, the 1st being called "moulded cork stoppers" and the 2nd "pre-machining stock" the 92.8 hours are the sum of the 42.6 hours spent on the first with the 50.3 spent on the second.

Right after the moulding step, moulded cork stopper bodies need to spend between 24 and 32 hours stabilizing, depending on their size, the quality department also checks for density or geometric problems during this time. After the cork stopper bodies have stabilized and quality has checked if they're within specifications in this step, the quality department is responsible for signalling that the batches are ok to be moved to the pre-machining stock.

Pre-Machining Cork Stopper Bodies

The 50.3 hours spent on average by inventories after the moulding process have no time restraint involved, it is only justified by waiting time for capacity allocation within the machining section's capacity.

To further elaborate on this wait time, it is important to note the remarks made previously in Chapter 3.4.5 Bottleneck Analysis. Even though there is an excess in capacity regarding cork stopper bodies, not all machines are compatible with all products. The most important of the groups is group 1, including Delta, SPI and Cristal which are about 50% of all production within this sector. This group also has the smallest gap between the machining and the moulding capacities, considering group 2 and 4 can share some machining lines, meaning that its bottleneck being the moulding machine is highly dependent on both the moulding and machining machines performance.

Another significant issue in the machining sector is that, despite having a real capacity that exceeds that of the moulding machines, not all machines can operate simultaneously. As discussed in the bibliographic review on "drum-buffer-rope," the machining section requires a certain number of workers to achieve full capacity. Since this process is not the bottleneck, the workforce was reduced to align the section's capacity with lower labour expenses. However, the actual number of workers in this section often falls below the planned three due to staff shortages or sick leave.

This reported capacity gap changed in May 2024 related to group 1's moulding capacity having increased, resulting in over-time requirements to satisfy this capacity increase as well as causing a WIP increase to 92 hours after this period.

This inventory will be further elaborated upon in Chapter 4.3.1: Pre-machining WIP problem.

Machined Cork Stoppers

After the machining process, the 29-hour inventory delay is primarily due to waiting for availability within the washing process capacity.

This delay is largely attributed to labour shortage in the machining lines, as the number of machining line workers is often below planned, considering that the washing process is also working above capacity, with a 65% capacity gap, it is common for workers in this section to assist in the machining process, further contributing to the wait time in this stock point.

Washed Cork Stoppers

The 19.6 hours wait time after the washing process can be justified partly by the time required for the cork stoppers to cool, which is required for the cork stopper to go through the electronic selection process, this limits this time to a minimum of 6 hours, the remaining hours also can be justified by the time waiting for allocation within the electronic selection process.

This inventory is within expectations considering that due to the electronic selection machines being above capacity, with a 97% capacity gap, it is common to stop 1 shift to help out in the machining process, hence leading to inventory growth.

Electronically Selected Cork Stoppers

The final and most significant inventory is the stock after the electronic selection process, which is responsible for 42% of production lead time.

Within this final inventory, lots are checked for quality, analysing for any visual issues, density problems as well as it's levels of TCA, all 3 production shifts are checked within the quality checking's only shift, after which the lots can be approved for proceeding to either be being directly shipped to BOURASSÉ facility in Tosse, or sent to the marking and coating sector in SOCORI, where products can then be directly shipped to the final client.

After the quality checking step, the remaining time spent in this inventory by items are mostly justified by the fact that many batches do not pass this test without requiring further quality corrective actions. While approved lots will spend significantly less time in inventory, lots that are rejected for many different reasons such as excessive humidity, high TCA levels, unacceptable ranges of density or having visual defects associated with them, dealing with these problems requires different corrective measures requiring significantly different times to fix the range of possible defects.

Another important note regarding this inventory was related to the elimination of the Pavilhão 3 stock point in the industrial unit, which at the time the VSM study was conducted was significantly impacting this stock point, however, this issue as well as a detailed inventory analysis will be conducted in Chapter 4.4.1: Quality Checking Step

In summary, the VSM illustrated in Figure 19 denotes significant issues regarding WIP inventory levels and consequent wastes related to excessive inventory levels and wait times.

To streamline the production chain, the two most relevant stock points were targeted in Chapter 4: Proposed Solutions and Benefit Analysis, namely the pre-machined stock point and the electronically selected stock point. These stock points will be further analysed and improved upon through the development of planning tools that ultimately aim to reduce inventory levels, and thus contributing to the broader goal of the transition to a more market-oriented production approach, with less waiting times and better time-to-market.

4 Proposed Solutions and Benefit Analysis

4.1 Action Plan

As explained in Chapter 3: Problem Description, this project did not approach the natural cork stopper sector. Due to the agglomerate cork stopper sector being responsible for supplying the technical sector with cork stopper bodies, as well as the fact that the agglomerate cork stoppers sales volume was the biggest of the 3 families, the agglomerate cork stopper sector was this project's main target.

To achieve the targeted leaner production chain with a focus on slow movers, WIP levels and Level of service, four solutions have been developed. This chapter will explore the motivation behind each solution, the details of the solution itself, and the degree of implementation success. Additionally, this introductory section will outline the overall action plan and approach taken throughout the project.

Regarding the Slow-Movers problem described Chapter 1: Context and motivation, the first solution was developed with the main goal of improving upon this issue and meeting the targeted decrease of Slow Movers in inventory by at least 50%. The Production Card Solution was the first project that was developed throughout the dissertation, it was based on the CONWIP approach, and targeted to completely eliminate the root cause of Slow Movers, which is further examined in Chapter 4.1.1: System Overview Before Implementation and Chapter 4.1.2: Overproduction Problem.

Improving upon the WIP level problems identified in Chapter 3: Agglomerate Section Value Stream Map included the development of 2 planning tools and 1 improvement project.

Aiming for solving the elevated WIP levels in the Pre-Machining stock point, the WIP problem was further examined, leading to the development of a Predictive Planning Tool for allocating the capacity of the Machining Sector, which predicted inventory levels of each cork stopper body based on the existing production plan of the previous step as well as the current inventory levels, aiming to promote a levelled production approach that would predict stock build up or stockouts ahead of the problem occurring.

In addition to the machining capacity planning tool, an improvement project was also successfully implemented, aiming to increase the capacity of the machining lines and therefore contribute to a better flow of items produced upstream in the moulding process and consequently a lower WIP levels in the Pre-Machining stock. Additionally, this project aims to further improve downstream stock points such as the machined cork stoppers and washed cork stoppers WIP levels, which were justified by the workers of these processes aiding in the machining process to improve its capacity by allowing a greater number of machines to work.

Finally, the very high WIP levels at the electronic selection were also targeted with a PowerBI visualization tool as well as small improvements to the MES System and quality's inventory

status registration CAE File. This tool aimed to allow further analysis upon this inventory that could be separated into 3 parts: 1. Items waiting for quality check 2. Approved items and 3. Blocked items that required corrective measures. This tool aimed to increase the response speed of the unit to quality problems as well as providing data-transparency to quality problems.

4.2 Production Card Planning Tool

4.2.1 System Overview Before Implementation

Regarding production planning, with the moulding process as the agglomerate section's bottleneck, the agglomerate C.S. section planned its production in this step, pushing the inventory of bodies after the moulding step to the next steps according to their standard routes, whenever an order arrived with a different route than standard, orders were given to manufacture it differently starting from the point of the route where the item wasn't processed in a standard way, see Figure 20.

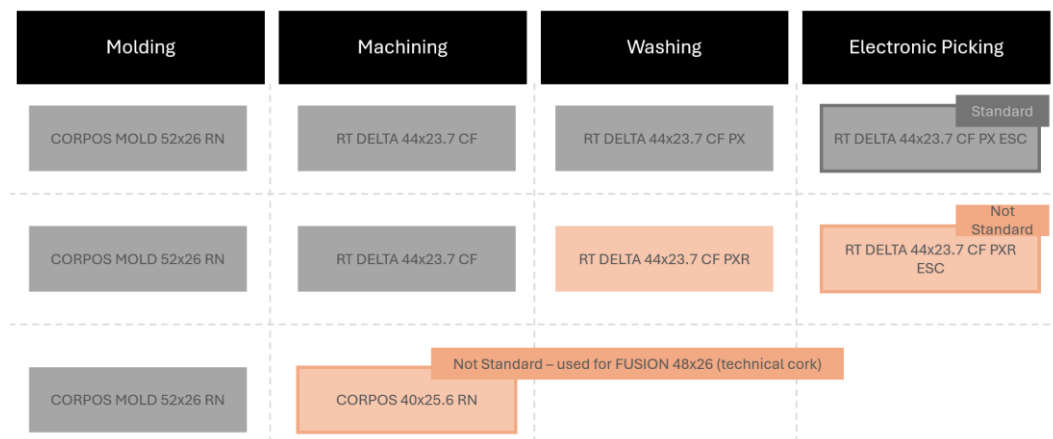


Figure 20: Standard VS Non-standard routes 52x26 RN C.S. Body

Overall production within the industrial unit is managed through a file called Order Planning Portfolio, where each order is registered, including the following information: 1. Requested items specifications and their quantity 2. Requested item traceback according to its manufacturing route 3. Final Client 4. Requested Order delivery date 5. Confirmed Expedition date 6. End of production date and 7. Tracing of the item's final customization steps, for all items that are marked, treated and sent directly to the final customer.

When a client places an order, the supply chain department starts by creating a delivery contract and updating the order book with the items requested, quantity, the client and the requested delivery date. Secondly, and regarding only the agglomerate and technical sectors in the unit, the production planner from the supply chain department checks for items in the current section's WIP or plans its manufacturing in the moulding process allocating the order within its capacity and confirms the expedition date, resulting in an end of production date estimation.

All sectors are managed to meet end of production dates planned by the supply chain department. In the technical cork stopper department, close coordination with the agglomerate sector is required in order to have a stable and reliable flow of cork stopper bodies that are required for the technical cork stopper production.

Agglomerate sector – AS IS Planning Model

Within the agglomerate cork stopper sector, the Agglomerate Sector Production Manager starts by checking the Order Planning Portfolio, checking existing stocks in all production steps and communicating with shift leaders on what items are needed to be produced, namely the quantity of each item to be produced, with special attention to non-standard items.

The moulding process mainly follows the production plan that is planned by the supply chain department, which decide when to do setups, stop and start the moulding machines, pushing cork stopper bodies to the pre-machining stock after the stabilization period.

Within the machining sectors production, machines are typically allocated to a type of cork-stopper body, which follows its standard route as cork stopper bodies are pushed into this process. With the supply chain department planning the previous step, the agglomerate manager is responsible for managing capacity and allocate the standard routes capacity to align the machining section with both the market and the moulding machines production capacity. Shift leaders coordinate each machining line, making sure the right items are being produced in the defined lines as well as planning machine setups and passing on information on non-standard items to produce, after which machining lines go back to producing standard items.

Regarding the washing step, shift leaders also coordinate workers on non-standard items to produce, everything else follows the standard route.

During the electronic selection step, shift leaders provide information on whether the final client is BOURASSÉ Chile, which requires items to be stored in special smaller bags after being electronically picked. No customization steps are done during this process.

For the final delivery, the quality department is heavily involved, as samples from each batch pass through a mandatory quality check-up, taking up to 24 hours to be checked. Once the quality department approves the lot, all cars within the lot can be allocated to final clients. This allocation is done through a printed sheet of paper with materials, quantities and destination, which is allocated to approved cars, making this the CODP of the sector.

4.2.2 Overproduction Problem

Currently, the information flow depends on 2 main mechanisms:

1. Shift leader indications for non-standard production, which happens verbally, requiring a high involvement in the process.
2. Printed sheets of papers with production orders to be produced that week which are regularly replaced.

During the project's duration, one of the main detected problems within the Agglomerate cork stoppers sector was that whenever a non-standard batch was requested, a common problem was the production of 1 or 2 extra cars, the proof of this problem is the Slow Mover inventory level at *Pavilhão 3*, which will be explained further in this chapter.

With SOCORI Industrial Unit following a Push approach for standard products, Non-standard were produced in a Pull approach, meaning that they were only produced when an order was made by a client, therefore, only the right number of non-standard units is requested and intended to be manufactured, everything else should follow the standard route.

Whenever an extra non-standard car was produced, as a non-standard item without an order, this car would be Pushed to a final stock point called *Pavilhão 3*, where it would remain for longer periods until either an order was made of that specific item or a rework of that material to a lower size was opted.

The root cause of this overproduction MUDA was further identified by a lack of communication between shifts, although one operator easily tracked how many carts were already produced within a non-standard order, how many were being produced in each process step and how many were left, difficulties rose in giving feedback on order processing progress between shifts, considering this section works in 3 shifts.

In order to keep track of this waste, a solution was developed through collaboration between the agglomerate cork section production managing team, including the production manager, the day shift leader and the supply chain department. This solution aimed to provide an intuitive order processing progress tracking method, with a primary focus on producing the right quantity of non-standard items at the right time.

4.2.3 Production Card Solution

The developed solution for solving the overproduction waste identified above was a production card tool. This tool is based on the concept of having a limited amount of physical production cards that limit the production of non-standard items, these cards should be placed on produced cards at their decoupling point, see Figure 21.

OF	1101318094
OV	7720006269/10
Nº KANBAN	24234 KB2
3 / 5	170 000 BOURRASSÉ CHILE
CORPO	CORPOS MOLD 52X26 RN
1. Retificação	44X23,7 CF RT DELTA 44X23,7 CF
2. Lavação	PX RT DELTA 44X23,7 CF PX
3. Escolha	CPK RT DELTA 44X23,7 CF PX ESC
Destino	RT DELTA 44X23,7 CF PX E E (BOURRASSÉ CHILE) 06/06/2024
ARTIGO NÃO STANDARD	

OF	1101318094
OV	7720006269/10
Nº KANBAN	24234 KB2
4 / 5	170 000 BOURRASSÉ CHILE
CORPO	CORPOS MOLD 52X26 RN
1. Retificação	44X23,7 CF RT DELTA 44X23,7 CF
2. Lavação	PX RT DELTA 44X23,7 CF PX
3. Escolha	CPK RT DELTA 44X23,7 CF PX ESC
Destino	RT DELTA 44X23,7 CF PX E E (BOURRASSÉ CHILE) 06/06/2024
ARTIGO NÃO STANDARD	

Figure 21: Non-standard cards for a Delta product

The tool symbolizes the CODP of any item, providing visibility on each car's destination and total order quantity. It was firstly developed for non-standard items, which have a non-standard route and therefore a CODP before the inventory after electronic selection.

Considering that standard items have a later CODP, their time-to-market does not include any of the manufacturing steps. With an earlier CODP, non-standard items are given manufacturing priority, directly influencing their time-to-market. The process was already occurring in this way, however, it lacked standardization and, as explained above, commonly resulted in overproduction and consequent Slow Movers.

The developed tool allows, however, to create a non-standard card for standard items if the item requires manufacturing priority, this can happen mostly because of a lack of quantity on standard items, commonly a result of a quality problem being detected at the end of the process,

and a significant part of the stock at this step being rejected with no option for rework, providing more flexibility to the tool.

The process of emitting cards relies on a macro enabled Excell Spreadsheet, see Figure 22. The developed tool allows the emission of cards through 5 steps:

1. Clicking on button “Atualizar Carteira” which updates the data from the Order Planning Portfolio as well as the Cork Stopper Bodies inventory Pivot Table which retrieves data from the MES database.
2. Filling in the OV which identifies each material order.
3. Fill in the quantity of cork stoppers to produce, this number will be used to calculate the number of Production cards to print out.
4. Select the OV’s that require to be printed
5. Click on button “Imprimir KANBAN’s”, which sends a signal to the predefined printer of the computer to print the selected production card in the amount sufficient to supply the specified number of cork stoppers.

	A	B	C	D	E	F	G
1							
2							
3							
4							
5							
6	OV	Quantidade	Quantidade em Falta	Inventário - CORPOS	Nº KANBAN	Cliente	Material
7	7720005970/10	160 000	160 000	1 303 163	24222 KB1	SOCIETA' AGRICOLA VALIANO S.R.L.	RT DELTA 44X23,7 CF PX M T E
8	7720006629/10	100 000	100 000	2 964 773	24222 KB2	BOURRASÉ S.A.S.	RT RUBI CRISTAL 44X23,7 CF PXR
9	7720004957/10	100 000	100 000	449 326	24222 KB3	BOURRASÉ S.A.S.	RE SPARK ONE 48X30 CF E
10	7720005558/10	60 000	60 000	-	24222 KB4	BOURRASÉ S.A.S.	RE CIDRA 45X28,8 EXTR E
11	7720005372/10	40 000	40 000	-	24222 KB5	BOURRASÉ S.A.S.	RE CH_ID 48X30 A CF ECO E

Figure 22: Macro-enabled Microsoft Excell spreadsheet production card interface

When step 1 and 2 are completed, the table that is responsible for feeding the information for the production card paper is automatically filled, retrieving all information from the Order Planning Portfolio, which was imported to the document via Query Table.

Information on the amount of cork stoppers in inventory, column “Inventário – CORPOS”, is also available allowing for a more data-driven card allocation decision, for most cases that will be allocated to the machining section.

The buttons responsible for printing the production cards and updating the MES Inventory Pivot Table and the Order Planning Portfolio Query worked through the code seen in Appendix B: VBA Production Cards Printing and Updating MACRO Code.

The implementation of the non-standard production cards was overall well accepted within the agglomerate cork stopper sector with good feedback from all stakeholders. Considering the standardization of this project, all agglomerate sector planning team members were now printing non-standard cards for all non-standard orders, which included the processing of defects as well as all non-standard product routes, using these cards as a Pull mechanism, representing a CODP within the production chain, with every standard item following a Push approach.

With several standard routes sharing the same cork stopper bodies, and the fact that each machine could include the processing of several standard routes, the machining section was still being planned in a verbal manner regarding setups and producing quantities. In order to aid the machining section planning, standard production cars were additionally developed. These standard production cards are an improvement to the communication mechanism for capacity planning, where the planners put the production cards into the sockets for each line, signalling a production order for the machine’s production, allowing the operators to be more independent regarding machine setup and when to do the setup, see Figure 23.

RT DELTA 44X23,7 CF PX ESC	
CORPO	CORPOS MOLD 52X26 RN
1. Retificação	RT DELTA 44X23,7 CF
2. Lavação	RT DELTA 44X23,7 CF PX
3. Escolha	RT DELTA 44X23,7 CF PX ESC
ARTIGO STANDARD	
! VERIFICAR DESTINO NA EMBALAGEM !	

Figure 23: Standard card for the Delta product

The standard cards, similarly to the non-standard cards were also well accepted by all factory operators, who value the visibility on the destiny of each car, as well as the added independence regarding their daily tasks.

Standard cards and non-standard cards have significant differences: 1) Visual: Standard cards have no information on the order, they are plasticized and are intended to be reusable. 2) Concept: Standard cards do not symbolize a CODP, they are allocated to a final delivery after the electronic selection and quality approval, therefore, an order was given to give priority to non-standard cards processing, in other words, all cards that are not plasticized.

4.2.4 Production card system results

Pavilhão 3, is a warehouse that belongs to Amorim Group and served as a replacement for the previous final items stock point that was replaced in SOCORI for the new Cristal Process. This stock point had all the items that were produced ahead of real orders; therefore, 3 reasons could justify the presence of items within the stock:

1. Production of standard items in advance to level out production with season market variability
2. The items are defects that are detected in the electronic selection process, these items have a REP or DEF tag to their name and will need to be reworked into a lower dimension or sold to the market as is. Production of REP happens in a Pull approach, where these items will be directed to client's orders.
3. Overproduction of non-standard items, which meant that originally the non-standard item was processed to be directed to a specific client's order, but an above requested quantity was produced instead, meaning that part of the produced items would then be sent to *Pavilhão 3*.

As a result of non-standard overproduction problems, the inventory in *Pavilhão 3* inventory is expected to be reduced by 16%, resulting in the inventory decrease of 1.1 million cork stoppers.

Additionally, due to the BOURASSÉ Group's alignment with the Amorim Group's production philosophy, this warehouse is predicted to cease operations by the end of 2024. This project represents a significant contribution to the unit's objectives, with an estimated annual expense of approximately €90,000 in operating costs, including the worker responsible for managing and stocking this stock, equipment and shipment costs. The 16% inventory reduction contribution to the total 7.0 million cork stoppers that compose this inventory, the additional contribution towards this goal was valued at €14,400 / year.

Regarding the implementation success, all non-standard items were produced with production cards starting on May 20th, with a total of 0 overproduced non-standard cars produced. Given the 4 weeks trial period, the expected results on this solution were very satisfactory, however a 70-100% success rate would quantify the project's WIP reduction between 0.8 to the total 1.1 million cork stoppers.

The project's goal of reducing Slow movers was therefore met by cutting non-standard items overproduction by 70-100%, contributing to the broader goal of achieving a leaner supply chain.

As a result of the standard production cards, a standardization of the machining capacity allocation as well as the information flow was improved, machining lines produce exactly the number of cards given to that specific line, shutting down after no cards were left, similarly, every car that would progress downstream would be processed as described in the production card, leaving fewer room for error. The benefits of this standardization start with contributing to the non-standard cards project being standardized as the new status quo of the unit. Additionally, they contribute to the information flow standardization, increasing the visibility on each cars future state, providing workers a greater deal of independence in production and allowing shift leaders an easier, faster and more mistake-free communication method.

4.3 Machining Process Planning Tools

4.3.1 Pre-machining WIP problem

As explained in Chapter 3: Problem Description, excessively high inventory levels were present at the pre-machining cork stopper bodies inventory, items spent on average 50.3 hours in WIP, or 3.6 million cork stopper bodies. Time spent in this inventory had no time restraint unlike the previous inventory that required 24-32 hours to stabilize, or the inventory after the washing process that required 6 hours before items could be electronically selected. Items in this inventory, therefore, waited to be allocated in the machining section's capacity to be produced.

In addition to the verified excessive levels of WIP in the pre-machining stock, a relevant change happened within the agglomerate cork stoppers manufacturing chain, the moulding machines significantly increased their production capacity for group 1, which previously had an estimated moulding capacity of ~ 39.8 thousand cork stoppers / hour throughout 2024, to an average hourly capacity of 54 thousand cork stoppers / hour in May. This significant change can be seen in Figure 24, which shows the volution on the average hourly capacity every 2 weeks in 2024.

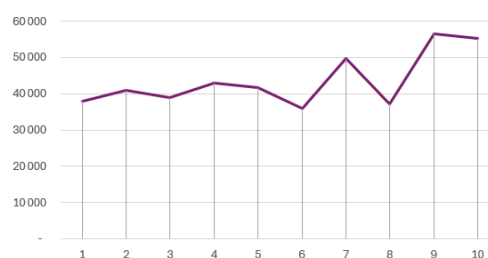


Figure 24: Hourly capacity evolution in the Moulding Process (2024)

This increase in capacity from 40 to 54 k cork stoppers / hour meant that the previous 41.7 k machining capacity could no longer process all the produced cork stoppers, meaning that the new group's bottleneck moved to the machining section. This bottleneck change led to a drastic WIP increase from the previous 52 hours in inventory verified up to 2024's week 19, to a significantly higher 92 hours in inventory from week 20 to week 23, see Figure 25.

Enhancing Manufacturing Performance in Cork Stopper Production: Planning Tools for WIP and Service Level Improvement

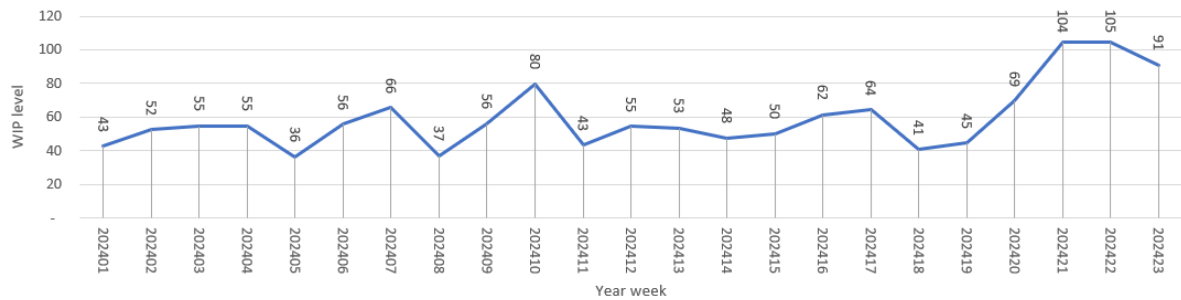


Figure 25: WIP weekly level evolution throughout 2024

With inventory growth being managed through the reallocation of lines 1 and 3 completely to group 1, increasing the previous 41.7k capacity to 46.9k, the lines capacity still lacked the capacity to process all moulded cork stopper bodies, therefore, overtime was utilized to deal with this difference in these lines.

A set of 2 solutions were developed to contribute to reducing the pre-machining WIP levels. The first solution targeted a predictive machining planning approach, that would align machine setups with the moulding machine capacity, predicting stock levels in advance and predicting both stockouts and stock buildups. The second solution mainly targeted to solve the capacity problem of the machining lines allocated to group 1, with a consequent effect on all further stocks as will be further explained in a later sub-chapter.

4.3.2 Machining Process Planning Tool

The machining process planning tool is a predictive approach to machining cork stopper planning, gathering information on current stocks from the MES database and predicting the future stock level evolution for all moulded cork stopper bodies.

As explained in Chapter 3: Agglomerate Section As Is Planning Model, the Moulding capacity and product allocation is managed by the Supply Chain Department, this planning is done through an excel file that states the production allocated to each moulding machine for the following weeks. This excel document is what dictates the Push production of cork stopper bodies that will then be directed to standard or non-standard routes via production card, and therefore provides the visibility of future production levels of each cork stopper body, considering the planned moulding machine product allocation, see Table 17.

Table 17: Moulding cork stopper bodies daily planned production table from June 6th to June 14th, 2024

workdays/week	5	5	5	4	4	4	4	4	4	4	5
workday?	1	1	0	0	0	1	1	1	1	0	0
day	202423	202423	202423	202424	202424	202424	202424	202424	202424	202424	202425
group week	06/06/2024	07/06/2024	08/06/2024	09/06/2024	10/06/2024	11/06/2024	12/06/2024	13/06/2024	14/06/2024	15/06/2024	16/06/2024
1 DELTA	300 000	300 000	-	-	-	300 000	300 000	300 000	300 000	-	-
1 CRISTAL	250 000	250 000	-	-	-	850 000	850 000	850 000	850 000	-	-
1 SPI	600 000	600 000	-	-	-	-	-	-	-	-	-
2 JUMP	200 000	200 000	-	-	-	-	-	-	-	-	-
2 JUMP CRISTAL	-	-	-	-	-	250 000	250 000	250 000	250 000	-	-
2 DXL	-	-	-	-	-	-	-	-	-	-	-
3 FUSION 44	250 000	250 000	-	-	-	250 000	250 000	250 000	250 000	-	-
3 NEW	-	-	-	-	-	-	-	-	-	-	-
3 NANO	-	-	-	-	-	-	-	-	-	-	-
4 CIGRADA29	240 000	240 000	-	-	-	250 000	250 000	250 000	250 000	-	-
4 CH 20	-	-	-	-	-	-	-	-	-	-	-

With the planned cork stopper production, an interface was made to allow for the cork stopper agglomerate sector planner to allocate each machine's daily capacity, see Table 18.

Table 18: Machining lines capacity allocation from June 6th to June 14th, 2024

Grupo	Linha	Cap (diária)	202423	202423	202423	202424	202424	202424	202424	202424	202424	202424	202424
			06/06/2024	07/06/2024	08/06/2024	09/06/2024	10/06/2024	11/06/2024	12/06/2024	13/06/2024	14/06/2024		
1	1	153 500	DELTA	DELTA				DELTA	DELTA	DELTA	DELTA	DELTA	DELTA
1	3	95 500	DELTA	DELTA				CRISTAL	CRISTAL	CRISTAL	NANO	STAL	STAL
1	7	346 400	SPI	SPI				CRISTAL	CRISTAL	CRISTAL	FUSION 44	STAL	STAL
1	8	324 000	SPI	SPI				CRISTAL	CRISTAL	CRISTAL	DELTA	STAL	STAL
1	9	206 333	CRISTAL	CRISTAL				CRISTAL	CRISTAL	CRISTAL	CRISTAL	STAL	STAL
2	14	139 400	JUMP	JUMP				JUMP CRISTA	JUMP CRISTA	JUMP CRISTA	SPI	P CRISTAL	P CRISTAL
3	4	370 500	FUSION 44	FUSION 44							CIDRA D29	ION 44	ION 44
3	5	149 000									JUMP		
3	6	283 333									JUMP CRISTAL		
4	10	115 800						JUMP CRISTA	JUMP CRISTA	JUMP CRISTA	DXL	P CRISTAL	P CRISTAL
4	11	158 750						JUMP	JUMP	JUMP	CH_2D	P CRISTAL	P CRISTAL
4	13	276 000	CIDRA D29	CIDRA D29				CIDRA D29	CIDRA D29	CIDRA D29	NEW	RA D29	RA D29
4	2	117 600											
0	12	0											

Considering machining lines allocation, two tables were developed, the first predicted the quantity within each inventory for the planned period in thousands of cork stoppers, see Table 19.

Table 19: Inventory prediction for cork stopper bodies from June 6th to June 14th, 2024

				5	6	7	1	2	3	4	5	6
Grupo	TRACK	INV (atual)	202423	202423	202423	202424	202424	202424	202424	202424	202424	202424
			06/06/2024	07/06/2024	08/06/2024	09/06/2024	10/06/2024	11/06/2024	12/06/2024	13/06/2024	14/06/2024	
1	DELTA	CORPOS MOLD 52X26 RN	1639	1639	1690	1690	1690	1690	1836	1983	2129	2276
1	CRISTAL	CORPOS MOLD 52X26 RN CRISTAL	2642	2642	2686	2686	2686	2686	2564	2442	2319	2197
1	SPI	CORPOS MOLD 52X26 RA AD	1325	1325	1254	1254	1254	1254	1254	1254	1254	1254
2	JUMP	CORPOS MOLD 52X32 RN JUMP	977	977	1037	1037	1037	1037	879	720	561	561
2	JUMP CRISTAL	CORPOS MOLD 52X32 RN CRISTAL	436	436	436	436	436	436	430	425	420	256
2	DXL	CORPOS MOLD 52X32 RN DXL	12	12	12	12	12	12	12	12	12	12
3	FUSION 44	CORPOS MOLD 42X26 RN	519	519	399	399	399	399	649	899	778	658
3	NEW	CORPOS MOLD 35X22 RN	1967	1967	1967	1967	1967	1967	1967	1967	1967	1967
3	NANO	CORPOS MOLD 42X26 RN NANO	-	-	-	-	-	-	-	-	-	-
4	CIDRA D29	CORPOS MOLD 50X32 RCT	1287	1287	1251	1251	1251	1251	1225	1199	1173	1147
4	CH_2D	CORPOS MOLD 46X35 RCT	256	256	256	256	256	256	256	256	256	256

Considering the yearly sales prediction, a daily production prevision was done for each cork stopper body, considering the unit's yearly workdays. With this daily production prevision, each inventory was converted into days in inventory, which is a better standardization of the visual tool considering sales levels for each item, see Table 20.

Table 20: Colour coded inventory prediction in days of inventory of cork stopper bodies from June 6th to June 14th, 2024

			week																
Gp	TRACK - DIAS INV	Previsão diária	INV	202423	202423	202423	202424	202424	202424	202424	202424	202424	202424	202424	202424	202424			
				06/06/2024	07/06/2024	08/06/2024	09/06/2024	10/06/2024	11/06/2024	12/06/2024	13/06/2024	14/06/2024							
1	DELTA	CORPOS MOLD 52X26 RN	429 889	3,8	3,8	3,9	3,9	3,9	3,9	4,3	4,6	5,0	5,3						
1	CRISTAL	CORPOS MOLD 52X26 RN CRISTAL	375 192	7,0	7,0	7,2	7,2	7,2	7,2	6,8	6,5	6,2	5,9						
1	SPI	CORPOS MOLD 52X26 RA AD	212 304	6,2	6,2	5,9	5,9	5,9	5,9	5,9	5,9	5,9	5,9						
2	JUMP	CORPOS MOLD 52X32 RN JUMP	89 811	10,9	10,9	11,6	11,6	11,6	11,6	9,8	8,0	6,2	6,2						
2	JUMP CRISTAL	CORPOS MOLD 52X32 RN CRISTAL	44 905	9,7	9,7	9,7	9,7	9,7	9,7	9,6	9,5	9,4	5,7						
2	DXL	CORPOS MOLD 52X32 RN DXL	27 629	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4						
3	FUSION 44	CORPOS MOLD 42X26 RN	240 291	2,2	2,2	1,7	1,7	1,7	1,7	2,7	3,7	3,2	2,7						
3	NEW	CORPOS MOLD 35X22 RN	267 128	7,4	7,4	7,4	7,4	7,4	7,4	7,4	7,4	7,4	7,4						
3	NANO	CORPOS MOLD 42X26 RN NANO	37 287	-	-	-	-	-	-	-	-	-	-						
4	CIDRA D29	CORPOS MOLD 50X32 RCT	269 055	4,8	4,8	4,6	4,6	4,6	4,6	4,6	4,5	4,4	4,3						
4	CH_2D	CORPOS MOLD 46X35 RCT	206 068	1,2	1,2	1,2	1,2	1,2	1,2	1,2	1,2	1,2	1,2						

This table was visually coded with a 3 colour scheme, with green signifying stocks that are within expected levels considering current performance, red marks all stock levels below 50% the average stock levels, predicting a stockout and stock levels above 50% signify either an imbalance between the group's production and consumption of cork stopper bodies or an overall indication of complete machining sectors inability to process all moulded bodies requiring either a moulding machine stoppage or a policy change regarding group allocation for machining lines.

This solution greatly benefits the agglomerate cork stopper planning routine in two major ways.

The first benefit is promoting a levelled production approach, tracking WIP levels for each product, contributing to lowering WIP levels in the pre-machining sector, as well as avoiding stockouts which would increase both technical and agglomerate cork stopper sections service levels.

Additionally, this predictive approach would predictively signify any need for policy changes both in the moulding process planning or the machining sectors group allocation.

4.3.3 Machining Process Capacity Improvement

As explained in Chapter 3.4.2: Machining Step, there are in total 14 machining lines, each with a different combination of machines.

5 machining lines are allocated to group 1, which composes 44% regarding the pre-machining cork stopper bodies WIP in June, compared to the average 3% in the previous months.

Regarding combination of machines, in group 1, all values can be seen in Table 21 with their estimated theoretical capacities extracted from the MES database.

Table 21: Group 1 machining lines machine number and theoretical capacity study

	Line 7	Line 8	Line 9	Line 1	Line 3
<i>Ponçadeiras</i>	6	6	6	4	2
<i>Topejadeiras</i>	2	2	2	2	1
<i>Chanfradeiras</i>	2	2	2	2	1
Line Real Capacity	13.5 k	13 k	10.5 k	5.8 k	3.5 k

As can be seen in Figure 24, the capacity increased to 54k cork stoppers / hour in May 2024. To meet this capacity and prevent stock build up, as well as allow a greater flexibility to solve inventory problems, higher capacity for this process would be optimal, namely from 47k to at least 54k, meaning an 7k / hour capacity increase, equivalent to a 15% capacity increase.

To improve lines 7, 8, 9, 1, and 3, a detailed study was conducted on machining line 8. This line was chosen for two main reasons. First, lines 7, 8, and 9 are responsible for the majority of production, therefore, targeting one of these lines promised a significant impact on overall production. Second, these lines operate in a similar manner, each equipped with the same number of machines and an identical automatic unblocking system that uses cylinders to unblock the *ponçadeira* machines. This system directly affects the availability of the machines. Consequently, any changes made to line 8 would inherently apply to the other two lines.

Analysing the performance improvement opportunities within machining line 8 involved two studies. The first was a theoretical cadence study, and the second focused on machine availability. These studies aimed to identify and address inefficiencies to enhance overall productivity.

The theoretical cadence study included a total of 5 samples taken from each machine, counting the amount of produced cork stoppers in 30 seconds, counting only continuous production without considering micro stoppages. For the availability study, a total of 5 samples were taken from each machine, counting the amount of produced cork stoppers in 2 minutes, without disregarding micro stoppages. It is important to note that this study further details the capacity variables within the machining lines, disregarding machine setups and downtime for maintenance reasons, including only micro stoppages related to small machine jams that are managed by the line operators. The results of study 1 and study 2 are resumed in Table 22.

Table 22: Machining line 8 capacity study

Machine	PON 1	PON 2	PON 3	PON 4	PON 5
Cadence (hour)	5 610	3 540	2 940	4 290	2 850
Availability	39%	73%	84%	92%	0%
Machine	PON 6	TOP 1	TOP 2	CH 1	CH 2
Cadence (hour)	4 020	9 840	10 080	10 200	10 440
Availability	89%	84%	69%	98%	97%
Group	PON	TOP	CH		
Total Cadence	23 250	19 920	20 640		
Avg. Availability	63%	76%	98%		
Capacity	14 643	15 229	20 137		

Firstly, an important note regarding the analysis of the results was that not all *ponçadeira* machines had unblocking cylinders, namely, *ponçadeira* 1 and 5 did not have this technology, requiring manual unjamming and thus resulting in much lower availability indexes, with *ponçadeira* 5 being jammed throughout the study period. Having cylinders is therefore an important factor regarding lines 7,8 and 9, as all 3 lines had this technology in the majority, but not all, *ponçadeira* machines.

Lastly, the bottleneck of line 8 was the *ponçadeira* machine, which has significant availability problems. When collecting data on the *ponçadeira* machines capacities, a very high standard deviation was detected, with an average daily capacity of 78 k. C.S./day the standard deviation regarding each machine's daily capacity was 26 k. C.S..

The *ponçadeira* machine was, as explained in Chapter 3.4.2: Machining Step, responsible for machining the outer diameter of the cork stopper to the desired final diameter, each machine consists in 1 rotating role that presses the cork stopper against a grinding stone. This process velocity was affected by 3 variables:

1. Motor speed – which affected the rotation speed of the rotating role
2. Role angle – which affected the tangential velocity that the role passed to the cork stopper, affecting the time spent by the cork stopper between the stone and the rotating role
3. Cork Stopper quality – increasing the machine's cadence has a maximum value above which diameter defects would start appearing in the cork stopper bodies.

With motor speed and role angles being calibrated by the maintenance operators, which aimed for the highest capacity possible for each machine without the presence of defects, new values were collected for all *ponçadeira* machines capacity as well as their respective rotation speed, see Table 23.

Table 23: Machining line 8 - *ponçadeira* machines capacity

	PON 1	PON 2	PON 3	PON 4	PON 5	PON 6
Cadence (hour)	5 610	3 540	2 940	4 290	2 850	4 020
r.p.m	176	124	124	144	160	160

As it can be seen, while rotation speed does justify some machines having a higher capacity than others, a great number of exceptions did not follow this rule, with *ponçadeira* 5 having a 160 r.p.m motor rotation speed with a 68k capacity and *ponçadeira* 3 producing 85k cork stoppers at only 124 r.p.m, this difference would only be justified by a different role angle.

Motor rotating speeds required an electrician to do setups and was typically kept constant throughout the year, with an effort to standardize these rotating speeds in the past years, it was concluded that the variable with the most influence on the current machine's cadence was the machine's role angle.

To understand if the machine had the optimum machining angle, where maximum machine cadence is achieved without the appearance of quality problems, an optimization process was made with one of the maintenance setup operators, where each machine's role angle was recalibrated, aiming for an increase in production cadence without compromising quality. After the setup adjustment was concluded, taking a total of 30 minutes, the resulting cadencies of each *ponçadeira* can be seen in Table 24.

Table 24: Theoretical capacity before and after role speed calibration

	PON. 1	PON. 2	PON. 3	PON. 4	PON. 5	PON. 6
Cadence (hour) - Before	5 610	3 540	2 940	4 290	2 850	4 020
Cadence (hour) - After	6 000	5 040	6 000	5 640	8 040	6 360

With the maintenance setup operators setting up the machines without the appearance of the 3 main quality problems: tilted body, inaccurate diameter and the deformation of the body, a control on the machined bodies verified the conformance to all the other defects that could be originated in this step, as the appearance of grooves in the cork stopper as well as other problems, confirming the success of the machine capacity setup. Considering the availability ratios verified in Table 22, the new capacity study of the line before and after the setup can be seen in Table 25.

Table 25: Before and after machine capacity prediction

	Ponçadeira Cap.	Topejadeira Cap.	Chanfradeira Cap.	Bottleneck
Capacity - Before	14 643	15 229	20 137	14 643 (Ponçadeira)
Capacity - After	23 354	15 229	20 137	15 229 (Topejadeira)

Given that with the *ponçadeira* capacity increase the bottleneck moved to the *topejadeira* process, the capacity improvement was of 586 cork stopper / hour or 70 k cork stoppers / week.

With the successful *ponçadeira* capacity increase, a prediction on machining capacity increase was conducted on lines 7 and 9. Regarding the availability of the lines, different availability was predicted for *ponçadeira* machines with and without unblocking piston mechanism, see Table 26.

Table 26: Machine availability assumptions

Machine	PON +	PON -	TOP	CF
Availability	75%	45%	75%	98%

Considering the same 60% capacity increase in the *ponçadeira* machines, and that line 7 has 6 *ponçadeira* machines with piston and line 9 has only 2, the expected weekly capacity increase of lines 7, 8 and 9 would be quantified at 8.8k, rising the machining capacity to 54.8 k, see Table 27, increasing the hourly capacity margin to from -8k to +0.8k.

Table 27: Weekly capacity increase prediction

	7 - Before	7 - After	8 - Before	8 - After	9 - Before	9 - After
PON	13 117	20 919	14 643	23 354	8 102	12 921
TOP	16 528	16 528	15 229	15 229	18 428	18 428
CH	22 645	22 645	20 137	20 137	21 088	21 088
Capacity	13 117	16 528	14 643	15 229	8 102	12 921
Cap. Increase	3.4 k (26%)		0.6 k (4%)		4.8 k (59%)	

An important remark to further improving machining lines 7 and 8 would be improving the availability of the *topejadeira* machines. During the machine availability measurements, a relevant problem regarding these machines availability was that they were left unattended for long periods of time, where the operator registered the completed cars in the MES system or loaded cars into the machine, with the standard procedure being 1 operator being allowed to leave at a time, and when he left the lines would be attended by the other operators, this rule was not being followed, and justified the 75% *topejadeira* availability, where the machine jammed, remained 20 minutes without production, after which the operator unjammed the machine which took approximately 30 seconds. If these availabilities were improved upon, for a 85% availability, the capacity increase of machine 7 and 8 would result in an additional 3.6 k cork stoppers/hour improvement.

The improvement implementation was done to all 7,8 and 9 lines. With the machining process capacity increase improvement being the last project within the dissertation timeline, the average results for the project's 2 last days after the implementation can be seen in Table 28.

Table 28: Capacity increase results

	Line 7	Line 8	Line 9
Real capacity (hour)	13.5k	13k	10.5k
Std. Dev (hour)	0.8k	1.6k	0.4k
Verified capacity (hour)	15.4k	12.7k	15k
Increase	1.9k (14%)	~0k	4.5k (43%)

The capacity improvement project was considered successful, with a capacity increase of 6.4k cork stoppers / hour, which result in a 768k cork stopper weekly capacity increase. The *ponçadeira* machines were the bottleneck of lines 7 and 8 as predicted, proved by the stopper *ponçadeira* machines and full buffers between the machines that were verified in the shopfloor.

With the moulding capacity planned for 2024 being ~50k, the resulting improvement of 6.4k took the current 46.9k to 53.3k cork stoppers, sending group 1's bottleneck back to the moulding machine.

Additionally, if the 10% improvement to the availability of the *topejadeira* machines, which would require an improvement on supervising machining lines 7,8 and 9, the capacity increase could go from the current estimated 53.3k to 56.9k, improving the capacity margin from 6.6% to 13.8%.

4.3.4 Machining Process Planning Tools Benefits

Regarding the first machining process solution, as explained above, the capacity planning tool aims to promote a levelled body production approach, predicting stock build up and future stockouts based on the predicted machining lines performance.

This solution's purpose will primarily target the state of this inventory before the WIP levels were affected by the capacity imbalance in group 1, namely, correct the already high levels of 52 hours in stock before week 19, equivalent to 3.7 million cork stoppers.

The idea behind this solution is to avoid stock build up but also predict stockouts which ultimately affect the service level of both the agglomerate and technical cork stopper sectors, increasing the reliability of the cork stopper bodies pushed to technical sector.

With the tool aiming to prevent stock build up, a study of the WIP levels of each group, identifying several inventory build-up spikes, see Figure 26, solving WIP build-up problems would decrease inventory levels by 911 k cork stoppers, a 25% improvement in WIP.



Figure 26: Inventory level weekly evolution 2024 - average value versus targeted value

The contribution towards preventing inventory stockouts would additionally contribute to increase the service levels of service of both the agglomerate and technical cork stopper sectors. Figure 27 shows the evolution of the Fusion's cork stopper bodies stock levels in the pre-machining WIP levels during April and May, as well as the occurrence of stockouts in the technical agglomerate sector.

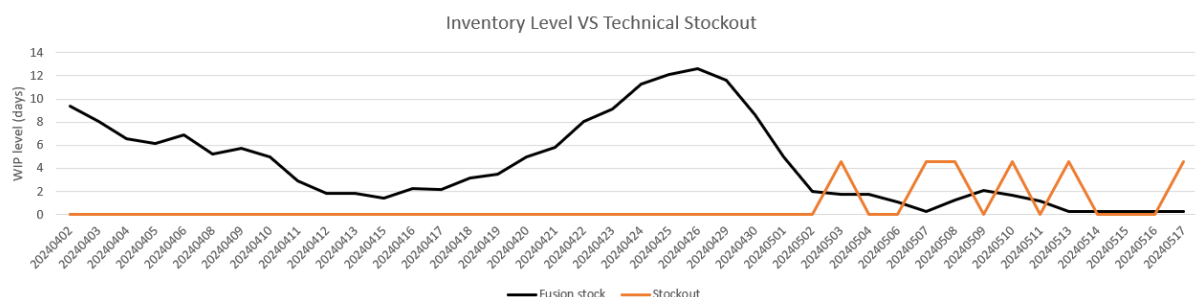


Figure 27: Fusion Pre-Machining WIP and Technical stockouts timeline from April 2nd to May 17th

From Figure 27, it is clear that the unhealthy WIP levels result in stockout problems in the Technical sector, the machining process planning tool also aims contribute to predict unhealthy low levels of WIP of cork stopper bodies, promoting a levelled production downstream, with a steady resource supply that would ultimately contribute to an improvement on the agglomerate sector service level supplying items to the technical sector as an internal client, ultimately contributing to a higher service level of both the technical and agglomerate cork stopper bodies.

Regarding the second WIP behaviour, as a result of capacity changes in the moulding machines, the WIP increase relative to the average WIP level was of 40 hours, or 2.9 million cork stoppers.

Given that the significant increase in the machining capacity would make the capacity gap between the machining and the moulding machine back to positive 6.6%, inventory is expected to start decreasing and slowly improve towards the previous WIP levels of 52 hours, a 43% improvement. This improvement can be further quantified in the previously needed 1 shift overtime, an 8-hour weekend shift, which has an estimated average cost of 16.6€/hour resulting in a €6,900 annual savings.

It is important to note that further improving the capacity of the machining line capacity through the improvement of the *topejadeira* machine availability, estimated to create a 13.8% capacity margin could contribute to an additional benefit in the WIP levels for washed and machined stock points. Considering that inventory levels at these stock points are justified mainly by the worker allocation to the machining section the current 29 and 20 hours of WIP could also be improved upon.

4.4 Inventory quality status visualization tool

4.4.1 Quality Checking Step

As mentioned in Chapter 3: Agglomerate Section Value Stream Map, the final inventory after the electronic selection step is the most significant inventory, being responsible for 44% of production lead time. During this time inventory quality state is checked, quality problems are dealt with corrective measures and inventory waits to be allocate to a client's order.

Quality state verification is a necessary step done to all produced lots, this verification is done in an 8-hour shift, where all lots from previous night and morning shifts are checked, and after these the most recent daily shift is checked. Considering balanced production, the estimated waiting time for a car should be 8 hours, see Figure 28. With the remaining 101 hours being explained by dealing with quality problems and allocate items to a client's order.

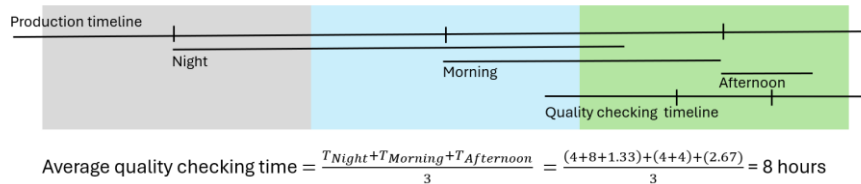


Figure 28: Estimated average quality checking time

The two main quality issues regarding this inventory include density problems, which require capacity allocation in the *ponderal* machine, dust problems, which require capacity allocation in the washing machine and humidity, which requires 48h of wait time before the lot is approved.

With the *pavilhão 3* stock point elimination, inventory that used to flow to this inventory stopped being directed to *pavilhão 3*. With that said, the WIP levels in the electronic selection were higher during the first months of 2024. Considering that inventory levels high level was corrected during 2024 without the influence of this project, inventory levels stabilized after 2024's 17th week, with an average value of 65 hours, see Figure 29.

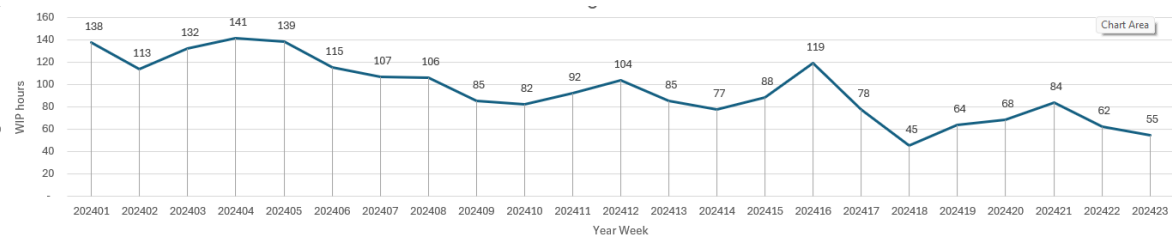


Figure 29: WIP Levels at electronic selected inventory

The performance of the current weighting machine's capacity was measured during the data collection in the machining step described in Chapter 3.4.2: Machining Step. The average wait time for 30 cork stoppers to be produced was 30.37 seconds per barrel, the weighting machine has 6 barrels in total resulting in a total capacity of ≈ 512 thousand cork stoppers. Considering that this machine's OEE is not 100%, and that during the whole project's period the machine was working with 5 of the 6 barrels, having 1 of the barrels not functioning, the estimated capacity included a 5/6 correction on the capacity plus a 95% availability estimation considering the time taken to load the cars and setup the machine, the total capacity estimated for the machine was 405 thousand cork stoppers / day.

In Table 29, the evolution of quality problems were tracked between the 17th and 23rd week. With humidity problems requiring a 48 hours stabilization period, dust problems being corrected at the rate of 107 k cork stoppers / hour and density problems being corrected at a rate of 405 k cork stoppers / hour, the corrective measures time required was estimated for each week, estimating an average of 19.5 hours between the 17th and 23rd week.

Table 29: Quality problems WIP evolution between 2024 17th and 23rd week

Week	202417	202418	202419	202420	202421	202422	202423
Density	4%	6%	18%	9%	23%	32%	17%
H%	3%	14%	1%	6%	11%	3%	17%
PÓ	10%	9%	4%	16%	22%	5%	14%
WIP	7,0	14,2	16,9	14,5	29,3	29,0	25,9

With 8 hours being estimated for the quality checking step and 19.5 hours being justified by corrective action, a total of 37.5 hours represent the time where the produced bags are either approved and are waiting to be packed or were rejected and are waiting for corrective action to be initiated, namely, *despoeiramento* or passing through the *ponderal* machine.

In 2024, 21% of cars required to go through the weighting machine, with a weekly standard deviation of 18%. With an average daily production rate of the electronic selection machine of 1 085 thousand cork stoppers in 2024, if 21% of production went through the weighting machine process, a daily capacity of 228 thousand cork stoppers would be needed in the *Ponderal* machine.

With an average daily utilization rate of 228,000 cork stoppers, the machine operates at approximately 56% capacity, equivalent to 13.51 hours or 1.68 shifts (based on 8-hour shifts). The substantial variability in the demand for weighing cork stoppers, as indicated by the high standard deviation, means that some days may require only one shift, while other days may need up to three shifts, potentially leading to delays due to insufficient capacity.

With that in mind, it is imperative that the agglomerate cork stopper production manager keeps track of how many cork stopper bodies are waiting to pass through the weighting machine and can rapidly respond to these corrective measures, which ultimately contribute to higher waiting times in this stock point.

In order to reduce WIP levels at the electronic selected stock point, the reactivity to corrective measures should be improved upon, with special emphasis on the weighting machine's capacity allocation. The quality status of all items was also of great value to the Supply Chain Department, as the quality status insights allow the production planner to track the status of each delivery as well as provide more accurate delivery dates to clients, hence improving the service level of the unit.

In collaboration with the quality department and the agglomerate section's production manager, it was concluded that the reason for this problem was that not all corrective measures could be dealt by the packaging worker alone, he was responsible for directing the cars to the appropriate corrective measures locations, but dealing with problems such as passing the lots through the weighting machine require capacity allocation which is the responsibility of the agglomerate sector production manager. The production manager, however, lacked the right tools to make fast decisions regarding quality problems, due to the fact that inventory is tracked via MES database in real time, but the quality status of lots being registered in a local Excell spreadsheet called the CAE File meant in order to check for what cars were approved, needed corrective action or were still waiting for quality status, the cars lot had to be searched in the MES database, and then the CAE File needed to be searched in order to check quality status. As the task of checking quality status on inventory items was very time consuming, it limited the Agglomerate Cork Stopper section's manager on the frequency that he could check this information, limiting his response speed to correcting quality problems.

In order to increase the Cork Stopper Sections Production Manager's response speed to quality problems, and consequently achieving the target of reducing the WIP of inventory after this step, two tools were developed in collaboration with the Quality Department and the Agglomerate Cork Stopper Production Manager.

The first tool, a PowerBI visualization tool, aimed to cross the MES database with the CAE File, organizing information on items in need for corrective action, items that are ready to be packed as well as providing a view on the amount of cork stopper within each product type that have each quality problem.

The second set of tools were designed to increase the impact of the first tool, it consisted in 3 main improvements:

1. The original CAE File was improved upon, standardizing the CAE File's information input and guaranteeing that quality data is passed on the PowerBI visualization tool.
2. A new stock point was created in the MES Database, namely the pre-ponderal stock, that allows for the agglomerate sections production manager to better manage the ponderal machine.
3. A Poka-yoke system was requested by the quality department to block the packaging of not approved cars, that would block any mistake of sending defective cars to clients that would ultimately affect the unit's level of service as well as result in costs.

4.4.2 Quality Status visualization tool

PowerBI Visualization Tool

As explained above, the inventory quality status visualization tool is a combination of 4 tools that aims primarily to increase the response speed and reactivity of the agglomerate cork stopper production to quality problems.

The core of the quality status visualization tool was developed in Microsoft Power BI, importing data from the local CAE File, which was saved in a local network file and crossing it with the information on the MES database.

On the CAE File, each line was identified as the combination of 4 columns, year, week, day and shift, which corresponds to the Lot information, as well as the 4 other columns, regarding class, calibre, washing and client, see Figure 30.

LOTE				Nºrelatório ECC	CLASSE	CALIBRE	Lavaç ão	Cliente
ANO	SEM ANA	DIA	TUR NO					
24	1	4	1	12	CDR - MOLD	45x28,8		SC
24	1	4	1	14	DELTA	44x23,55	PX	CPK
24	1	4	1	15	RUBICRISTAL	48x23,55	PXR	CPK
24	1	4	1	16	CDR - EXT	45x28,8		SC
24	1	4	2	26	CDR - MOLD	45x28,8		SC
24	1	4	2	24	CDR - EXT	45x28,8		SC
24	1	4	2	23	DELTA	44x23,55	PX	CPK

Figure 30: CAE File row identification columns

Integrating this solution to the inventory in the MES database firstly required the creation of an ID that would identify each row within the quality database, this ID was achieved through the combination of 2 main parts: the lot in each row and the material of each row.

Regarding the creation of the first part of the ID variable, the lot was achieved through the concatenation of the year, week, weekday and shift, adding the SY code of the client code is SY and SC for all the remaining cases, being organized in the same manner as the MES database: TTYWWDS (TT- Type of lot; YY- Year; WW- Week; D – Day and S – Shift). This code was generated in the Power Query editor of PowerBI.

For the second part of the ID variable, the conversion was not as direct as the previous part as will be explained later in this chapter. To solve this issue, two possible solutions were possible: 1) Creating a conversion table to connect these table and generate a compatible ID between the databases considering the lack of standardization in the CAE File or 2) Standardize the quality document and make this connection error free. The second approach was the one opted.

Connecting both parts resulted in an ID code that identified all the MES inventory that had a quality report, which included all the inventory but the ones that were classified as either a defect that were to be sold directly to the market at a lower cost or a *repasse* item which were to be machined to a lower size and sold as a different product.

As can be seen in APPENDIX C: Quality Status PowerBI tool, 5 visualization panes were developed for the 3 stakeholders: 1. Agglomerate Sector Planning Team 2. The Supply Chain Department and 3. The Quality Department. The first two pains include visualization on lot status as well as quality status by car, targeted for the agglomerate sector planning team. The second two include an improved inventory checking tool that was developed for the supply chain department, as well as a quality status visualization tool that allows to see further details on each item's quality problems, as the same items can be blocked for many reasons, each reason with a different corrective measure timing. The final pane was developed for the quality department, and includes graphs on the CAE File, as well as a filtering tool for the quality status of each big bag, allowing to summarize how many big bags have each quality problem, the product family distribution by quality problem as well as the amount of cork stoppers that are currently blocked and therefore require corrective measures.

CAE File Standardization

As explained above, the lack of standardization within the CAE File was a relevant issue when developing the quality status visualization tool, two main areas were identified to require standardization: the material identification and the quality results registration.

Regarding the first area in need for standardization, the material identification, the previous way of registering the material in each row can be seen in Figure 31. The standard Delta material name in the MES database after the electronic selection is RT DELTA 44x23.7 CF PX ESC.

As can be seen in Figure 31, the same material is identified as DELTA, 44x23.55, with a PX washing. The first issue with this conversion on this specific material is regarding the 44x23.55 calibre, which refers to the same cork calibre but uses an old sizing dimension instead. The second issue with this conversion is regarding the CF part of the material, which was added a chamfer during the machining process, which is the product's standard route, but no information is given on this regard. Other issues occur with other materials such as the material of the RE CIDRA 45X28.8 ESC product, that is registered in the file as CDR – MOLD, as a way of distinguishing it from the previous production bodies that were extruded that still existed from the previous production year. These issues resulted in the incompatibility of identifying the materials within the CAE File and therefore providing a quality report on the MES Inventory.

Nºrelatório ECC	CLASSE	CALIBRE	Lavação
12	CDR - MOLD	45X28.8	
14	DELTA	44X23.55	PX
26	CDR - MOLD	45X28.8	
23	DELTA	44X23.55	PX

Figure 31: CAE File material identification

As previously stated, the first and simpler solution was to create a conversion table to connect these table and generate a compatible ID between the databases, which would require periodic updates if any new item was added. This option had the issue of possibly hiding results that simply didn't have a match in the conversion table and therefore made the tool less reliable and consequently less trustworthy and overall less valuable.

The option to standardize the quality document and make this connection error free was opted as besides the advantage of making the data crossing easier, it was also designed to improve the speed at which information was registered about the material.

The new CAE File was developed in collaboration with the quality department. This file was designed to automatically fill both the lot information as well as the Material, Class, Caliber and Washing of the lot by reading the *Etiqueta* which is the bar code that identifies each car within the MES database, see Figure 32.

Atualizar MES (MACRO)							
Etiqueta	Ano	Semana	Dia	Turno	Classe	Calibre	Lavação
J0074822870	24	20	2	2	CIDRA	45X27	-
J0074903739	24	20	4	1	DELTA	42X26,5	PX
J0075006638	24	20	6	1	SPI	44X23,7	PX
J0075008686	24	20	6	1	SPI	44X23,7	PX

Figure 32: New developed CAE File lot and material identification columns

The new CAE File gets the information from a pivot table that checks current MES Inventory and utilizes a MACRO that both copies the current inventory to a table that registers all historical data so that the file information on past lots is kept but also updates the current inventory table. The option to load all the lots from the year 2024 was not opted because it took a long time to load, namely 40 seconds where the excel screen was frozen, while this option not only took 5-10 seconds to load.

The new file also concatenates the Lot and Material MES codes in hidden columns which provides a direct error free quality report ID that enables smooth crossing of the two databases.

Regarding the second area in need for standardization, two columns were used to provide information on the quality problems regarding each report as well as the corrective actions to

be made, namely the Observations column and the Technological Director decision, which was the person responsible for making some decisions regarding corrective actions, like derogating items to specific clients, meaning that the client's specifications match the lot's current quality state for minor quality problems and therefore the lot would be directed to that specific client or other specific decisions such as weighting the cork stopper. These columns often mixed information, as can be seen in Figure 33. Additionally, some typos appeared throughout the extensive list of about 900 results from January 2024 to May 2024. Considering the lack of standardized data of the old CAE File and the new need for extracting meaningful quality data reports to a visualization tool, a new approach was taken in the new CAE File.

APÓS PONDERAL CF	PASSAR PONDERAL
DENSIDADES BAIXAS=PASSAR PONDERAL/ POUCA QUANTIDADE MISTURADO NA PONDERAL COM O LOTE 240832	PASSAR PONDERAL

Figure 33: Observations and Technological Director decision columns from old CAE File

The new CAE File replaced the two Observations column and Technological Director decision columns with the 3 columns: causes, actions and observations, see Figure 34. Both causes and actions columns had a standardized dropdown list. This dropdown list retrieved information from a table that was made in collaboration with the quality department and included all causes, combination of causes as well as all actions and combination of actions possible, this table included all information of 2024 so far, but can easily be updated by the quality department if a new case occurs.

Causas	Ações	Observações lab
Densidades baixas + Resíduos	Passar na ponderal + Recontrolar	Enviar
Densidades baixas + Resíduos	Aguarda PA + Recontrolar	Passar na ponderal até 310
Densidades baixas	Derrogado	Derrogado para marcação

Figure 34: New developed CAE File cause-actions columns

The first column, causes, will be used in the data crossing as a way of providing meaningful statistics regarding the current quality problems within the electronic selection inventory. The second column, actions, will be used in a view for the packaging worker to manage and direct lots to their corrective action destinations. The last column, observations, will be used to pass on any additional information such as derogation details or other non-standard information.

In order to fill the table automatically, development was requested to an external entity to print each bar code two times after each car is produced, so that one of these remained in the car and the second was provided to the quality department. Two other items needed development which were described in the two following chapters, however, it is important to note that this functionality already existed in other industrial units within Amorim Group, but were not available in SOCORI, the development consisted in implementing in SOCORI this already existing functionality.

Pre-Ponderal Stock Point

Aiming to improve the reactivity of the agglomerate cork stopper planner to allocate the *ponderal* machine capacity, a new stock point was created in the MES Database, namely the *pre-ponderal* stock. This stock point completely separates the cars that require to go through the weighting machine, allowing for close monitoring regarding the weighting machine's shift allocation as well as the sections performance of dealing with this issue throughout the year.

The creation of this stock point was also developed by an external entity along with the double bar code printing and the third development which will be described in the last solution regarding the inventory status visualization tool.

Poka Yoke packaging solution

The current method for transmitting information on whether or not a lot, and all referred cars, were previously communicated to the packaging worker that dealt with sending the bags to their final destination was to print out quality status cards, if the status read “OK” the packaging worker would send the big bag to the final destination, see Figure 35.

ETIQUETA POS CONTROLO
LOTE
241333
PRODUTO
CDR - MOLD
Calibre
45X28.8
Lavação
0
Cliente
SC
QUANTIDADE BBS
2
TGA
0.5
ESTADO
OK
DERROGAÇÃO
0
OBS
0
APÓS RECONTROLO DE IN - CF

Figure 35: Quality status communication card

This method was flawed in some ways, such as the fact that when multiple results occurred within the same lot the only difference for example between SC and SY lots within the same shift, day and week was the first two letters of the lot that was written in small letters in the big bag, see Figure 36; or that the only difference between lots of the same material was the final numbers; or that the same material rarely had a different than standard washing, meaning that the field *Lavação* seen in the card differentiating PX with PXR might lead to some confusion. Overall, the system led to a lot of room for flaws, and mistakes often occurred when allocating the ticket to the big bag, leading to future delays of sending the car back and substituting it with the correct one which ultimately affected the final date given to the client, which affected the unit’s level of service. With all the previous developments that were required, the technological director requested for a solution to improve this process and make it mistake-free as well as easier for the operator.



Figure 36: Big bag identification tag

The number of unapproved big bags that were mistakenly packed in 2024 up to week 23 can be seen in Figure 37.

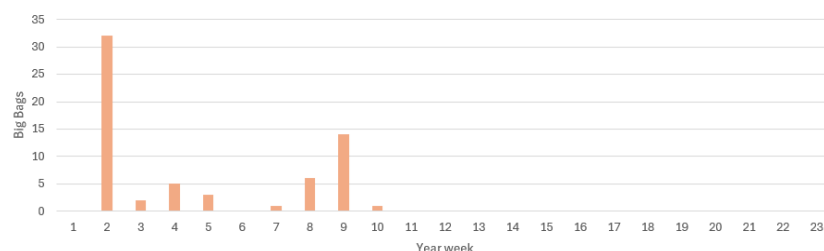


Figure 37: Unapproved big bags packed in 2024

The solution was designed in collaboration with the Quality Department, the Agglomerate Cork Stopper Production Manager and was the third item requested for development by the external entity, this functionality, once again, already existed in other Industrial Unit’s within the Amorim Group. It included a new blocking procedure of all cars that would only be unlocked by the quality department.

The new system works as follows:

1. Adding a new status variable to all produced cars / big bags that would be empty by default, electronic selection would produce big bags with a blocked value in this variable.
2. The quality department would get the copy of the bag's identification bar code, when the lot is approved, all bar codes would be registered in the MES database and changed to an approved status.
3. When a bag was approved, the worker that directs the big bag to the final destination needed to scan the bar code in order to digitally make this movement visible, now when he reads the bar code, the status variable appears in the visualization screen and it reads "blocked" the movement is blocked by the system, meaning that there was a mistake in the quality card placement.

One of the system's main benefits is that it makes the system error free, but it also enables the quality card system to futurely be entirely replaced by a visual tool that allows for the worker to see all approved lots and cards without the placement of this quality card, which was started during the time spent in the company, but as the development was not completed until the end of the project's period, it's full implementation could not be completely achieved.

Another main driver towards this development's approval was that the quality status variable would be of great value to the Agglomerate Sectors Production Planner, as filtering inventory by quality status in the MES database gives visibility on the history of ready to pack inventory and assess these items individually, allowing for performance assessments and identifying improvement opportunities.

4.4.3 Quality Status Visualization tool benefits

The quality status visualization tools were mainly implemented throughout the last 2 weeks of the project's timeline. The tools aim to reduce the electronic selected WIP through 3 main mechanisms:

1. Improving the reactivity to corrective measures by a real-time easy access to quality status information of each car
2. Visualization on the evolution of the inventory levels with the approved status and the pre-ponderal stock point allows for performance assessment and future work upon the approved lots waiting time and *pre-ponderal* waiting time.
3. Visualization of quality of defects by all stakeholders allows for a more reactive approach upstream, decreasing quality problems and WIP indirectly

With an average WIP of 65 hours where the first 8 are explained by the quality status verification waiting time and 19.5 hours being explained by corrective measures required timings, a total of 37.5 hours are estimated to be spent either waiting to be packed or waiting for corrective measures. The 37.5 hours in WIP are equivalent to 2.2 million cork stoppers, 58% of the total inventory.

The WIP improvement of this process is especially relevant in non-standard items, due to the CODP being located before the electronic selection process, therefore, WIP reduction would result in a closer time to market, improving it up to 37.5 hours.

Regarding service level, this inventory level is very relevant specially for non-standard products, with 38% of bags in 2024 having no quality issues, the remaining bags would have significantly higher time spent in this inventory. With the increased reactivity to quality problems, the variability of time spent in inventory of items is expected to decrease, therefore making the production lead time of these items more predictable, positively affecting the service levels of the unit.

Additionally, other benefits can be identified such as the Poka-Yoke contribution for a more mistake-free packaging process; the quality checking of each lot was made faster and a closer collaboration between the quality department and agglomerate sector planning team was achieved.

5 Conclusions

In the context of SOCORI Industrial Unit's broader goal of achieving a more market-oriented production approach, this project's focus was to contribute to a leaner manufacturing chain by identifying waste and targeting its reduction through the development of planning tools.

The project targeted the agglomerate cork stopper sector for three reasons: 1. The agglomerate cork stoppers compose a greater sales volume %, 2. The agglomerate cork stoppers sector is responsible for supplying the technical sector with a steady flow of cork stopper bodies 3. The natural cork stopper sector production follows a Push approach, with production being very dependent on received cork batches.

Regarding the first project's objective of identifying the production bottleneck and waste within the unit's manufacturing chain, the study showed the molding process as the bottleneck of the sector, with 1 exception being made for group 1's products, where the machining sector has a close capacity margin in comparison to the molding process, becoming the bottleneck in May 2024 after the molding machine's hourly capacity increased from 40 to 54 thousand cork stoppers.

Slow movers were identified to be stocked in *Pavilhão 3*, consisting in non-standard MTO items that were overproduced throughout 2023 and 2024, the total Slow Mover inventory was quantified as 1.1 million cork stoppers, or 16% of the total 6.9 million cork stopper inventory that was additionally justified by production capacity levelling of certain articles as well as generated defects that are inherent to the agglomerate cork stopper production. The developed solution consisted in a production card tool that allocates produced cars and big bags to client's orders, therefore physically limiting the number of non-standard produced cars because no more than the printed cars can be produced through the non-standard route, this tool was successfully implemented in the shopfloor, being used daily as a means of coordinating production, a total of 0 agglomerate cork stopper Slow movers were produced between May 20th and June 14th. The production cards also contributed to the standardization of the production communication method, providing greater independence for production workers, as well as allowing shift leaders an easier and faster communication method.

In addition to the previously described overproduction waste, a second waste was identified, a total of 92.8 hours were spent by every item, on average, between the molding and the machining process, with the first 42.6 hours being spent stabilizing for a 24-32 hours in addition to a quality check process, the remaining average 50.3 hours spent in the pre-machining stock point were justified by 1 of 2 things: 1- buffer levels for resource management within the molding machines, which worked on 1 product only every week or 2- waiting to be allocated within the machining sector.

With the molding machine being planned by the supply chain department in alignment with market demand predictions and client orders, a problem was identified on the resource allocation within the machining lines, leading to unlevelled production, which resulted in inventory peaks during the year as well as stockouts. With the vision of creating a planning tool that aligns the molding process with the machining capacity allocation, promoting healthy WIP levels, preventing inventory growth as well as stockouts, this tool allowed the agglomerate cork

stopper section planner to plan out each machining line's capacity according to a prediction on future stock levels, which exploded the current inventory to the predicted levels considering the molding capacity plan, this tool was implemented during the internships last week, being utilized weekly by the agglomerate section planner as a standard tool for the planning of the machining lines capacity. The inventory buildup problem was quantified in a total of 911k cork stoppers, 25% of the 3.7 million cork stopper inventory that composed the pre-machining stock point. This tool will allow for better data-driven decisions on the machining line's capacity allocation, further contributing to a smoother cork stopper body supply to the technical sector, improving the sector's service levels.

As a result of the capacity increase on the molding machine's capacity from 42 to the new planned 50 thousand cork stoppers, an improvement project was made to increase the capacity on group 1's machining lines capacity, namely, the improvement on the *ponçadeira* machines that compose the first machining process of each machining line, a capacity increase of 6.4k rose the previous 46.9k machining line capacity in group 1 to 53.3k, allowing for the solving of this problem as well as increasing the productivity of lines 7 and 9, as well as the potential improvement on all machining lines. This improvement project also identified the *topejadeira* machines availability problem as a further improvement opportunity to increase each line's productivity. The solving of this capacity difference is predicted to improve the overtime requirement in the machining section to compensate the previous 3.1k capacity gap, which resulted in an extra shift during the weekend, with an annual cost of €6,900 as well as allowing for an inventory reduction to the previous levels, contributing to a 2.9 million cork stopper inventory reduction, which represents a 40% of stock after the capacity change.

The final identified waste was related to the stock point after the electronic selection, where cars spent an average of 65 hours waiting in stock. Of these, 37.5 hours were due to waiting to be packed or awaiting corrective measures, impacting approximately 2.2 million cork stoppers. With no information on the MES database on quality status, checking the quality status of each lot in inventory was a time-consuming process, as well as the lack of visibility on the past quality status of each inventory made the study on this inventory difficult, allowing only the estimation to the occurrence of problems in the CAE File, but not when they were solved or waited for corrective measures. With the main goal of improving data visibility on quality status of every item in inventory, a PowerBI visualization tool was developed, as well as other related projects which required to be development by an external entity. While the PowerBI visualization tool was fully implemented and being utilized by the quality department, supply chain department and the agglomerate cork stopper planning team, the 3 additional externally developed projects were not completed at the time the internship ended.

Overall, all planning tools were fully implemented and being utilized by all related stakeholders, the only exception being the externally developed projects related to the PowerBI that do not affect the performance and overall value of the tool within the industrial unit.

The identified wastes were quantified in WIP levels amounting to 7.111 million cork stoppers, leading to the following outcomes: 1) A 16% inventory improvement related to Slow Mover production was achieved. 2) A potential 25% improvement from better alignment of the molding and machining processes, with an additional predicted 43% improvement from enhanced machining capacity and 3) A potential 58% improvement related to reducing wait time waste in the electronically selected inventory.

The developed planning tools further contribute towards a better information flow in the Industrial Unit, the Supply Chain department is now able to assign orders to electronically selected lots through a faster PowerBI tool, see Appendix B, and the agglomerate section planner can see the bags that require corrective actions faster. These improvements affect both the non-standard items time to market with a potential of a 37.5-hour improvement but also

standard cars, given that the order allocation is expected to be faster, with the easy access to quality status.

The standardization of the information flow on the planning orders being allocated as early as the machining section, the non-standard production cards, as well as the Poka-Yoke solution that is expected to be implemented later this year also contribute to a greater independence of the workers, making overall overproduction, as well as other mistake related wastes less frequent.

With future work including the finishing on the externally developed quality status visibility projects as well as the possibility of further improving the machining line's productivity by improving on the *topejadeira* process, the overall developed tools as well as the capacity improvement projects were concluded with a significant impact towards achieving the broader goal of contributing to a leaner manufacturing chain.

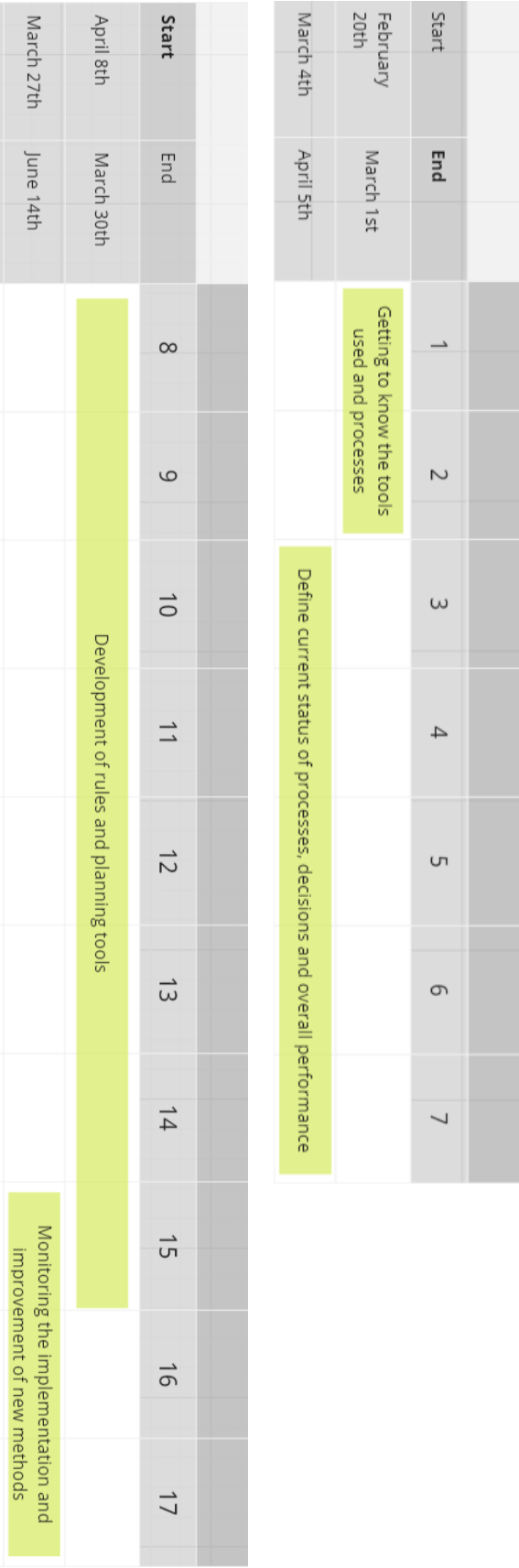
6 Bibliography

- Amorim Cork. (2017, July 19). *Press Release*. https://Www.Amorim.Com/Xms/Files/v1/Investidores/7_Comunicados/20170718Infor-macaoPrivilegiada.Pdf.
- Arunagiri, P., & Gnanavelbabu, A. (2014). Identification of major lean production waste in automobile industries using weighted average method. *Procedia Engineering*, 97, 2167–2175. <https://doi.org/10.1016/j.proeng.2014.12.460>
- Bond, T. C. (1999). The role of performance measurement in continuous improvement. In *International Journal of Operations & Production Management* (Vol. 19, Issue 12). # MCB University Press. <http://www.emerald-library.com>
- Cannas, V. G., Gosling, J., Pero, M., & Rossi, T. (2019). Engineering and production decoupling configurations: An empirical study in the machinery industry. *International Journal of Production Economics*, 216, 173–189. <https://doi.org/10.1016/j.ijpe.2019.04.025>
- Corporate Finance Institute. (n.d.-a). *Make To Order (MTO)*. <https://Corporatefinanceinstitute.Com/Resources/Management/Make-to-Order-Mto/>.
- Corporate Finance Institute. (n.d.-b). *Make To Stock (MTS)*. <https://Corporatefinanceinstitute.Com/Resources/Management/Make-to-Stock-Mts/>.
- Corticeira Amorim SGPS S.A. (n.d.). *Corticeira Amorim: O maior grupo de transformação de cortiça do mundo*. <https://Www.Amorim.Com/Pt/Corticeira-Amorim/Overview/>.
- Corticeira Amorim SGPS S.A. (2022). *CORTICEIRA AMORIM RELATÓRIO E CONTAS INDIVIDUAIS*.
- Gunaki, P., Devaraj, S., & Patil, S. (2022). Process optimization by value Stream Mapping. *Materials Today: Proceedings*, 54, 251–254. <https://doi.org/10.1016/j.matpr.2021.08.304>
- Gundogar, E., Sari, M., & Kokcam, A. H. (2016). Dynamic bottleneck elimination in mattress manufacturing line using theory of constraints. *SpringerPlus*, 5(1). <https://doi.org/10.1186/s40064-016-2947-1>
- Hall, R. W. (1987). *Attaining Manufacturing Excellence: Just-in-time, Total Quality, Total People Involvement*. Dow Jones-Irwin.
- Hayes, A. (2024, July 3). *Make-to-Order (MTO) or Made-to-Order: Definition and Example*. <https://Www.Investopedia.Com/Terms/m/Make-to-Order.Asp>.
- Hopp, W. J., & Spearman, M. L. (2004). To pull or not to pull: What is the question? *Manufacturing and Service Operations Management*, 6(2), 133–148. <https://doi.org/10.1287/msom.1030.0028>
- Imai, M. (1986). *Kaizen: The Key To Japan's Competitive Success*. McGraw-Hill Education.
- Kosky, P., Balmer, R., Keat, W., & Wise, G. (2020). *Exploring Engineering: An Introduction to Engineering and Design* (Fifth Edition).

- Kumar, C. S., & Panneerselvam, R. (2007). Literature review of JIT-KANBAN system. *International Journal of Advanced Manufacturing Technology*, 32(3–4), 393–408. <https://doi.org/10.1007/s00170-005-0340-2>
- LJUBENović, Ž. (2019). *Equity Research - CORTICEIRA AMORIM S.G.P.S., SA: Vertical and horizontal integration*. Lisbon School of Economics and Management.
- Olhager, J. (2003). Strategic positioning of the order penetration point. *International Journal of Production Economics*, 85(3), 319–329. [https://doi.org/10.1016/S0925-5273\(03\)00119-1](https://doi.org/10.1016/S0925-5273(03)00119-1)
- PLANETTOGETHER. (2021, June 28). *Advantages and Disadvantages of Make to Order*. <https://www.planettogether.com/blog/advantages-and-disadvantages-of-make-to-order>
- Prakash, J., & Chin, J. F. (2014). Modified CONWIP systems: A review and classification. In *Production Planning and Control* (Vol. 26, Issue 4, pp. 296–307). Taylor and Francis Ltd. <https://doi.org/10.1080/09537287.2014.898345>
- Raut, L. P., Wakode, R. B., Talmale, P., & Steels Pvt Ltd, B. (2015). Overview on Kanban Methodology and its Implementation Overview on Kanban Methodology and its Implementation Student 2 Assistant Professor 3 Production Manager 1,2 Department of Mechanical Engineering. In *IJSRD-International Journal for Scientific Research & Development* (Vol. 3). <https://www.researchgate.net/publication/280865949>
- Rohac, T., & Januska, M. (2015). Value stream mapping demonstration on real case study. *Procedia Engineering*, 100(January), 520–529. <https://doi.org/10.1016/j.proeng.2015.01.399>
- Saniuk, A., & Waszkowski, R. (2016). Make-to-order manufacturing - New approach to management of manufacturing processes. *IOP Conference Series: Materials Science and Engineering*, 145(2). <https://doi.org/10.1088/1757-899X/145/2/022005>
- Schroeder, D. M., & Robinson, A. G. (1991). *America's Most Successful Export to Japan: Continuous Improvement Programs*. <https://sloanreview.mit.edu/article/americas-most-successful-export-to-japan-continuous-improvement-programs/>
- Segal, T. (2022, October 5). *Make To Stock (MTS)*. <https://www.investopedia.com/terms/m/make-to-stock.asp>
- Şimşit, Z. T., Günay, N. S., & Vayvay, Ö. (2014). Theory of Constraints: A Literature Review. *Procedia - Social and Behavioral Sciences*, 150, 930–936. <https://doi.org/10.1016/j.sbspro.2014.09.104>
- Singh, J., Kalan, K., & Singh, H. (2009). *Kaizen Philosophy: A Review of Literature Kaizen Philosophy: A Review of Literature*. <https://www.researchgate.net/publication/268284725>
- Singh, J., & Singh, H. (2015). Continuous improvement philosophy – literature review and directions. *Benchmarking*, 22(1), 75–119. <https://doi.org/10.1108/BIJ-06-2012-0038>
- Spearman, M. L., Woodruff, D. L., & Hopp, W. J. (1990). CONWIP: A pull alternative to kanban. *International Journal of Production Research*, 28(5), 879–894. <https://doi.org/10.1080/00207549008942761>
- Stevenson, M., Hendry, L. C., & Kingsman, B. G. (2005). A review of production planning and control: The applicability of key concepts to the make-to-order industry. In *International Journal of Production Research* (Vol. 43, Issue 5, pp. 869–898). <https://doi.org/10.1080/0020754042000298520>

- Tatiana, K., Karkoszka, T., & Szewieczek, D. (2007). *Risk of the processes in the aspect of quality, natural environment and occupational safety*.
<https://www.researchgate.net/publication/42253357>
- Theory of Constraints Institute. (n.d.). *Theory of Constraints (TOC) of Dr. Eliyahu Goldratt*.
<https://www.tocinstitute.org/theory-of-constraints.html>.
- Timberg, L. (2024, March). *Make-to-order (MTO) vs. make-to-stock (MTS)*.
<https://katanamrp.com/blog/make-to-order-vs-make-to-stock/>.
- Vorne Industries Inc. (n.d.). *THEORY OF CONSTRAINTS (TOC)*.
<https://www.leanproduction.com/theory-of-constraints/>.

APPENDIX A: Project Development Gantt Chart



APPENDIX B: VBA Production Cards Printing and Updating MACRO Code.

```
Sub Imprimir_KANBAN_2ForPag()  
  
    Dim n As Integer           'total fichas  
    Dim p As Integer           'posicao pagina  
    Dim pp As Integer          'n° páginas  
    Dim StrQuantidade As String  
    Dim Quantidade As Integer   'quantidade na ficha  
    Dim Codigo As String  
    Dim StrKANBAN As String  
    Dim KANBAN As String       'número de KANBAN  
    Dim Standard_BIN As Integer  
    'limpar página  
    Sheets("FILL").Cells.Clear  
  
    'formatar  
    Worksheets("FILL").Columns("A:M").ColumnWidth = 7  
    Worksheets("FILL").Columns("A:M").RowHeight = 13  
  
    'posicao pagina  
    StrRangeb = "A1:F32"  
    StrRange1 = "A1:F32"  
    StrRange2 = "H1:M32"  
    StrCell1 = "C6"  
    StrCell2 = "J6"  
    StrCellQ_1 = "A7"  
    StrCellQ_2 = "H7"  
  
    n = 1  
    p = 1  
    pp = 1  
  
    Sub UpdateAllFields()  
        Dim ws As Worksheet  
        Dim pt As PivotTable  
        Dim qt As QueryTable  
  
        ' Refresh all pivot tables  
        For Each ws In ThisWorkbook.Worksheets  
            For Each pt In ws.PivotTables  
                pt.RefreshTable  
            Next pt  
        Next ws  
  
        ' Refresh all query tables  
        For Each ws In ThisWorkbook.Worksheets  
            For Each qt In ws.QueryTables  
                qt.Refresh  
            Next qt  
        Next ws  
  
        ' Refresh all data connections  
        ThisWorkbook.RefreshAll  
  
        ' Calculate all worksheets  
        For Each ws In ThisWorkbook.Worksheets  
            ws.Calculate  
        Next ws  
  
        MsgBox "Tabela SOC foi atualizada.", vbInformation  
    End Sub  
  
    'para cada elemento selecionado  
    For Each sel In Selection  
  
        'quantidade por ficha  
        StrQuantidade = "K" & sel.Row  
        Quantidade = Worksheets("Inputs").Range(StrQuantidade).Value  
        StrKANBAN = "E" & sel.Row  
        KANBAN = Worksheets("Inputs").Range(StrKANBAN).Value  
  
        For i = 1 To Quantidade  
  
            If p = 1 Then  
                'limpar página  
                Sheets("FILL").Cells.Clear  
                Worksheets("Template_AGLO").Range(StrRangeb).Copy  
                Worksheets("FILL").Range(StrRange1).PasteSpecial  
                Worksheets("FILL").Range(StrCell1).Value = KANBAN  
                Worksheets("FILL").Range(StrCellQ_1).Value = "" & i & " / " & Quantidade  
            Else  
                If p = 2 Then  
                    Worksheets("Template_AGLO").Range(StrRangeb).Copy  
                    Worksheets("FILL").Range(StrRange2).PasteSpecial  
                    Worksheets("FILL").Range(StrCell2).Value = KANBAN  
                    Worksheets("FILL").Range(StrCellQ_2).Value = "" & i & " / " & Quantidade  
                End If  
            End If  
  
            If p = 2 Then  
                Worksheets("FILL").PrintOut Preview:=False, Copies:=1  
                p = 1  
            Else  
                p = p + 1  
            End If  
  
            n = n + 1  
        Next i  
    Next  
  
    If IsEmpty(Worksheets("FILL").Range(StrCell2).Value) Then  
        Worksheets("FILL").PrintOut Preview:=False, Copies:=1  
    End If  
  
End Sub
```

APPENDIX C: Quality Status PowerBI conversion table

Qual_ID	Material Name 2
AGL_RCT_38X22,8_PX	RT AGL_RCT 38X22,8 CF PX ESC
AGL_RCT_38X23,55_PX	RT AGL_RCT 38X23,7 CF PX ESC
AGL_RCT_40x24,50	RT AGL_RCT 40X24,5 CF ESC
AGL_RCT_47X29,5_ECO	RT AGL_RCT 47X29,5 CF ECO ESC
CDR - EXT_40X27	RE CIDRA 40X27 EXTR_ESC
CDR - EXT_42X27	RE CIDRA 42X27 EXTR_ESC
CDR - EXT_45X27	RE CIDRA 45X27 EXTR_ESC
CDR - EXT_45X28,8	RE CIDRA 45X28,8 EXTR_ESC
CDR - EXT CF_45X27	RE CIDRA 45X27 CF EXTR_ESC
CDR - EXT CF_45X28,8	RE CIDRA 45X28,8 CF EXTR_ESC
CDR - MOLD_40X27	RE CIDRA 40X27 ESC
CDR - MOLD_45X27	RE CIDRA 45X27 ESC
CDR - MOLD_45X28,8_PX	RE CIDRA 45X28,8 PX ESC
CDR - MOLD_45X28,8	RE CIDRA 45X28,8 ESC
CDR - MOLD CF_45X27	RE CIDRA 45X27 CF ESC
CDR - MOLD CF_45X28,8	RE CIDRA 45X28,8 CF ESC
DELTA_38X23,55_PX	RT DELTA 38X23,7 CF PX ESC
DELTA_38X23,55	RT DELTA 38X23,7 CF ESC
DELTA_41X28,5_PX	RT DELTA 41X28,5 CF PX ESC
DELTA_41X28,5	RT DELTA 41X28,5 CF ESC
DELTA_42X26,5_PX	RT DELTA 42X26,5 CF PX ESC
DELTA_42X27_PX	RT DELTA 42X27 CF PX ESC
DELTA_44X23,55_PX	RT DELTA 44X23,7 CF PX ESC
DELTA_44X23,55_PXR	RT DELTA 44X23,7 CF PXR ESC
DELTA_48X23,55_PX	RT DELTA 48X23,7 CF PX ESC
RUBI_44X23,55_ECO	RT RUBI 44X23,7 CF ECO ESC
RUBI_44X23,55_PX	RT RUBI 44X23,7 CF PX ESC
RUBI_44X23,55_PXR	RT RUBI 44X23,7 CF PXR ESC
RUBI_48X23,55_ECO	RT RUBI 48X23,7 CF ECO ESC
RUBI CRISTAL_44X23,55_PXR	RT RUBI_CRISTAL 44X23,7 CF PXR ESC
RUBI CRISTAL_48X23,55_PXR	RT RUBI_CRISTAL 48X23,7 CF PXR ESC
SPI_36X23,5_PX	RT SPI 36X23,5 CF PX ESC
SPI_38X23_PX	RT SPI 38X23 CF PX ESC
SPI_38X23,55_PX	RT SPI 38X23,7 CF PX ESC
SPI_38X23,55	RT SPI 38X23,7 CF ESC
SPI_44X23,55_PX	RT SPI 44X23,7 CF PX ESC
CDR - EXT CF_40X27	RE CIDRA 40X27 CF EXTR_ESC
RUBI_48X23,55_PXR	RT RUBI 48X23,7 CF PXR ESC
AGL_RCT_33X22_PX	RT AGL_RCT 33X22 CF PX ESC
CDR - MOLD_42X28,8	RE CIDRA 42X28,8 ESC
CDR - MOLD CF_42X28,8	RE CIDRA 42X28,8 CF ESC
SPI_44X23,55	RT SPI 44X23,7 CF ESC

APPENDIX D: Quality Status PowerBI

PowerBI tool



Consulta Geral Inventário

Material

DELTA 44X23,7

Q

Lote

Search

Q

SOCORI

Groupe Bourassé

Material

Múltiplas seleções

Local

Tudo



LocationAltName	RT DELTA 44X23,7 CF	RT DELTA 44X23,7 CF PX	RT DELTA 44X23,7 CF PX ESC	RT DELTA 44X23,7 CF PXR	Total
ISOC Linha EE 02		40.000		40.000	
ISOC Stock Escolha Aglo			1.010.184	1.010.184	
ISOC Stock Receção MTE			2.000.554	2.083.470	
ISOC Stock Rolhas Lavadas AGLO		318.242		318.242	
ISOC Stock Rolhas Retificadas AGLO	200.000			200.000	
Total	200.000	358.242	3.010.738	82.916	3.651.896

Consulta Inventário Escolha - Resultados CAE

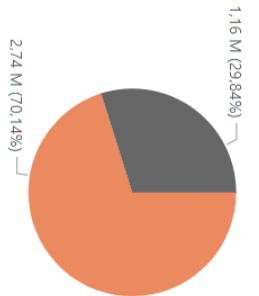
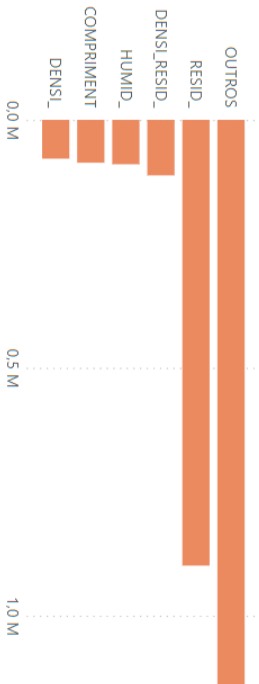
MaterialName	SC	Estado	QTD	LocationAltName	
RT DELTA 44X23,7 CF PX ESC	SC	Bloqueado	702.392	ISOC Stock Escolha Aglo	
RT DELTA 44X23,7 CF PX ESC	SC	Pronto	241.979	ISOC Stock Escolha Aglo	
Total			944.371		

LocationAltName	MaterialName	Lot	QTD
ISOC Stock Escolha Aglo	RT DELTA 44X23,7 CF PX ESC	SC242143	160.033,00
ISOC Stock Escolha Aglo	RT DELTA 44X23,7 CF PX ESC	SC242451	138.286,00
ISOC Stock Escolha Aglo	RT DELTA 44X23,7 CF PX ESC	SC242441	136.484,00
ISOC Stock Escolha Aglo	RT DELTA 44X23,7 CF PX ESC	SC242452	111.942,00
ISOC Stock Escolha Aglo	RT DELTA 44X23,7 CF PX ESC	SC242442	111.627,00
ISOC Stock Escolha Aglo	RT DELTA 44X23,7 CF PX ESC	SC242453	102.280,00
ISOC Stock Escolha Aglo	RT DELTA 44X23,7 CF PX ESC	SC242443	101.773,00
ISOC Stock Escolha Aglo	RT DELTA 44X23,7 CF PX ESC	SC242461	65.813,00
ISOC Stock Escolha Aglo	RT DELTA 44X23,7 CF PX ESC	SC242433	31.939,00
ISOC Stock Escolha Aglo	RT DELTA 44X23,7 CF PX ESC	SC242342	31.779,00
ISOC Stock Escolha Aglo	RT DELTA 44X23,7 CF PX ESC	SC242343	18.228,00
Total			1.010.184,00

Material	SC_SY	QTD	Estado	Razão_DET	Depósito
RE CIDRA 45X28,8 CF ESC	SC	65.811	Bloqueado	HUMID_	ISOQ Stock Escolha Aglo
RE CIDRA 45X28,8 CF ESC	SC	263.728	Bloqueado	OUTROS	ISOQ Stock Escolha Aglo
RE CIDRA 45X28,8 ESC	SY	2.967	Bloqueado	OUTROS	ISOQ Pavilhão 3
RE CIDRA 45X28,8 ESC	SC	26.213	Bloqueado	COMPRIMENT	ISOQ Stock Escolha Aglo
RE CIDRA 45X28,8 ESC	SC	150.551	Bloqueado	OUTROS	ISOQ Stock Escolha Aglo
RE CIDRA 45X28,8 EXTR. ESC	SY	23.695	Bloqueado	HUMID_	ISOQ Pavilhão 3
RT DELTA 38X23,7 CF PX ESC	SC	78.165	Bloqueado	DENSL_	ISOQ Pavilhão 3
RT DELTA 38X23,7 CF PX ESC	SC	18.573	Bloqueado	OUTROS	ISOQ Pavilhão 3
RT DELTA 44X23,7 CF PX ESC	SC	111.942	Bloqueado	DENSL_RESID_	ISOQ Stock Escolha Aglo
RT DELTA 44X23,7 CF PX ESC	SC	102.280	Bloqueado	OUTROS	ISOQ Stock Escolha Aglo
RT DELTA 44X23,7 CF PX ESC	SC	488.170	Bloqueado	RESID_	ISOQ Stock Escolha Aglo
RT RUBI CRISTAL 44X23,7 CF PYR ESC	SC	60.157	Bloqueado	COMPRIMENT	ISOQ Stock Escolha Aglo
RT SPI 36X23,5 CF PX ESC	SC	14.513	Bloqueado	OUTROS	ISOQ Pavilhão 3
RT SPI 44X23,7 CF PX ESC	SC	596.101	Bloqueado	OUTROS	ISOQ Stock Escolha Aglo
RT SPI 44X23,7 CF PX ESC	SC	410.784	Bloqueado	RESID_	ISOQ Stock Escolha Aglo
Total		2.118.385			

CLASSE	CALIBRE
✓ Selecionar tudo	✓ Selecionar tudo
✓ AGL_RCT	✓ 36X23,5
✓ CDR - EXT	✓ 38X23,55
✓ CDR - EXT CF	✓ 40X27
✓ CDR - MOLD	✓ 41X28,5
✓ CDR - MOLD CF	✓ 42X26,5
✓ DELTA	✓ 42X27
✓ RUBI	✓ 42X28,8
✓ RUBI CRISTAL	✓ 44X23,55
✓ SPI	✓ 45X27
	✓ 45X28,8

✓ SC
✓ SY

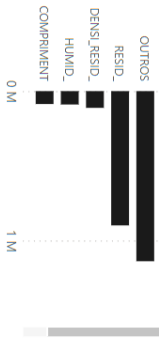
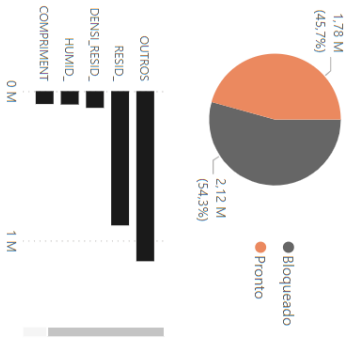


Location
ISOQ Stock Escolha Aglo
ISOQ Pavilhão 3
ISOQ Ponderal Aglo

Enhancing Manufacturing Performance in Cork Stopper Production: Planning Tools for WIP and Service Level Improvement

Depósito	Material	LOT_ID	QTD	Estado	Razão	Observações
[SOC] Pavilhão 3	RE CIDRA 45X28.8 ESC	SY240222	2.967	Bloqueado	outros	POUCA QUANTIDADE
[SOC] Pavilhão 3	RE CIDRA 45X28.8 ESC	SY240223	57.033	Pronto	-	MOLD 7
[SOC] Pavilhão 3	RE CIDRA 45X28.8 ESC	SY240231	62.687	Pronto	-	COMPRIMENTOS ELEVADOS
[SOC] Pavilhão 3	RE CIDRA 45X28.8 ESC	SY240232	57.313	Pronto	-	COMPRIMENTOS ELEVADOS DERROGADO PA
[SOC] Pavilhão 3	RE CIDRA 45X28.8 ESC	SY241242	30.000	Pronto	-	APÓS RECONTROLO H% CF
[SOC] Pavilhão 3	RE CIDRA 45X28.8 ESC	SY241243	103.490	Pronto	-	APÓS RECONTROLO H% CF
[SOC] Pavilhão 3	RE CIDRA 45X28.8 ESC	SY241251	83.231	Pronto	-	
[SOC] Pavilhão 3	RE CIDRA 45X28.8 ESC	SY241252	85.733	Pronto	-	
[SOC] Pavilhão 3	RE CIDRA 45X28.8 ESC	SY241253	21.132	Pronto	-	H% ELEVADA = APÓS RECONTROLO CF
[SOC] Pavilhão 3	RE CIDRA 45X28.8 EXTR_ESC	SY240231	32.543	Pronto	-	
[SOC] Pavilhão 3	RE CIDRA 45X28.8 EXTR_ESC	SY240252	23.695	Bloqueado	Humidade	H% ELEVADA - APÓS RECONTROLO = NCF - RECONTROLOAR NOVAMENTE
[SOC] Pavilhão 3	RE CIDRA 45X28.8 EXTR_ESC	SY240431	59.989	Pronto	-	APÓS RECONTROLO DE H% = CF
[SOC] Pavilhão 3	RE CIDRA 45X28.8 EXTR_ESC	SY240433	19.273	Pronto	-	H% ELEVADA APÓS RECONTROLO CF
[SOC] Pavilhão 3	RE CIDRA 45X28.8 EXTR_ESC	SY240441	5.127	Pronto	-	APÓS RECONTROLO DE H% = CF
[SOC] Pavilhão 3	RE CIDRA 45X28.8 EXTR_ESC	SY240442	30.232	Pronto	-	APÓS RECONTROLO DE H% = CF
[SOC] Pavilhão 3	RE CIDRA 45X28.8 EXTR_ESC	SY240532	22.889	Pronto	-	DENSIDADES BAYAS= DERROGADO PA
[SOC] Pavilhão 3	RT DELTA 38X23.7 CF PX ESC	SC240022	78.165	Bloqueado	Densidade	DENSIDADES ELEVADAS= DERROGADO PA + NC11/2/24 - FETTA UMA 2ª PASSAGEM - TESTE DE ABS= ELEVADA - DERROGADO
[SOC] Pavilhão 3	RT DELTA 38X23.7 CF PX ESC	SC240033	15.423	Pronto	-	DENSIDADES BAYAS= DERROGADO PA
[SOC] Pavilhão 3	RT DELTA 38X23.7 CF PX ESC	SC240032	18.573	Bloqueado	outros	POUCA QUANTIDADE
[SOC] Pavilhão 3	RT DELTA 38X23.7 CF PX ESC	SC240033	81.430	Pronto	-	DENSIDADES BAYAS= derogadas por PA
[SOC] Pavilhão 3	RT DELTA 38X23.7 CF PX ESC	SC240041	63.418	Pronto	-	DENSIDADES BAYAS= derogadas por PA
[SOC] Pavilhão 3	RT DELTA 42X26.5 CF PX ESC	SC240032	19.782	Pronto	-	APÓS VENTILAR - RESÍDUOS= 0,5 ACETE POR PA
[SOC] Pavilhão 3	RT DELTA 42X26.5 CF PX ESC	SC240032	7.357	Pronto	-	APÓS VENTILAR - RESÍDUOS=0,5 - ACETE PA
[SOC] Pavilhão 3	RT DELTA 42X26.5 CF PX ESC	SC240943	7.881	Pronto	-	APÓS VENTILAR RESÍDUOS=0,5 - ACETE PA
[SOC] Pavilhão 3	RT DELTA 42X26.5 CF PX ESC	SC241232	44.535	Pronto	-	
[SOC] Pavilhão 3	RT DELTA 42X26.5 CF PX ESC	SC241233	31.314	Pronto	-	
[SOC] Pavilhão 3	RT RUBI 44X23.7 CF PX ESC	SC240852	10.455	Pronto	-	RESÍDUOS - DESQ ASSINICADO DE RUBI PARA DELTA - PARA MARCAÇÃO PARA ENCONTRO DE DELTA
[SOC] Pavilhão 3	RT RUBI 44X23.7 CF PX ESC	SC240853	29.552	Pronto	-	DENSIDADES BAYAS=DERROGADAS PA - ENVIAR PARA A MARCAÇÃO
[SOC] Pavilhão 3	RT RUBI 44X23.7 CF PX ESC	SC241343	19.095	Pronto	-	APÓS PONDERAL DENSIDADES BAYAS= PASSAR PONDERAL ZX = CF + COMPRIMENTOS BAYOS=DERROGADO PA
[SOC] Pavilhão 3	RT SPI 38X23.5 CF PX ESC	SC240052	14.513	Bloqueado	outros	POUCA QUANTIDADE
[SOC] Pavilhão 3	RT SPI 38X23.5 CF PX ESC	SC240053	25.377	Pronto	-	
[SOC] Ponderal Aglo	RT RUBI_CRYSTAL 44X23.7 CF	SC242133	742	Pronto	-	
Total			3.901.666			75

CLASSE	CALBRE
✓ Seleccionar tudo	✓ Seleccionar tudo
✓ AGL_RCT	✓ 36X23,5
✓ CDR - EXT	✓ 38X23,55
✓ CDR - EXT CF	✓ 40X27
✓ CDR - MOLD	✓ 41X28,5
✓ CDR - MOLD CF	✓ 42X26,5
✓ DELTA	✓ 42X27
✓ RUBI	✓ 42X28,8
✓ RUBI CRISTAL	✓ 44X23,55
✓ SPI	✓ 45X27
	✓ 45X28,8
	✓ 47X29,5
	✓ 48X23,55



Selecionar tudo		[SOC] Ponderal Aglo				[SOC] Stock Escolha Aglo			
Material	Lot	Etiqueta	QTD	Estado	Estado Final	TCA	Observações	Depósito	
RT SPI_44X23,7 CF PX ESC	SC242441	J0075902344	27	Pronto	OK	0,79		[SOC] Stock Escolha Aglo	1
RT SPI_44X23,7 CF PX ESC	SC242442	J0075860498	5,220	Pronto	OK	1,8	Após estabilizar = CF	[SOC] Stock Escolha Aglo	1
RT SPI_36X23,5 CF PX ESC	SC242051	J0074967246	46,728	Pronto	OK	0,49	NCI 98/24	[SOC] Stock Escolha Aglo	1
RT RUBI_CRISTAL_48X23,7 CF PX ESC	SC242153	J0075356044	14	Pronto	Derrogado	0,5	DENSIDADES ELEAVDAS	[SOC] Stock Escolha Aglo	1
RT RUBI_CRISTAL_44X23,7 CF PX ESC	SC242133	J0075350455	742	Pronto	OK	0,5		[SOC] Ponderal Aglo	1
RT RUBI_CRISTAL_44X23,7 CF PX ESC	SC242142	J0075349421	15	Pronto	OK	0,49	DENSIDADES ELEAVDAS APÓS PONDERAL CF	[SOC] Stock Escolha Aglo	1
RT RUBI_CRISTAL_44X23,7 CF PX ESC	SC242151	J0075349842	7	Pronto	Derrogado	0,5	DENSIDADES ELEAVDAS	[SOC] Stock Escolha Aglo	1
RT RUBI_CRISTAL_44X23,7 CF PX ESC	SC242431	J0075899458	27	Pronto	OK	0,5		[SOC] Stock Escolha Aglo	1
RT RUBI_CRISTAL_44X23,7 CF PX ESC	SC242432	J0075898112	6	Pronto	OK	0,5	COMPRIMENTOS ELEAVDOS + DENSIDADES ELEAVDAS - DERROGADO POR PA + 288 S/P/ ENVAGUAR	[SOC] Stock Escolha Aglo	1
RT RUBI_CRISTAL_44X23,7 CF PX ESC	SC242441	J0075899664	28	Pronto	OK	0,5	2 88 S/P/ ENVAGUAR	[SOC] Stock Escolha Aglo	1
RT RUBI_CRISTAL_44X23,7 CF PX ESC	SC242441	J0075900254	11	Pronto	OK	0,5	2 88 S/P/ ENVAGUAR	[SOC] Stock Escolha Aglo	1
RT RUBI_CRISTAL_44X23,7 CF PX ESC	SC242442	J0075848584	50,008	Pronto	Derrogado	0,5	DENSIDADES ELEAVDAS - derrogadas por PA	[SOC] Stock Escolha Aglo	1
RT RUBI_CRISTAL_44X23,7 CF PX ESC	SC242442	J0075848584	50,008	Pronto	Derrogado	0,5	RETIFICADO EM 45X23,85 / COMPRIMENTOS ELEAVDOS + DENSIDADES ELEAVDAS - DERROGADO POR PA	[SOC] Stock Escolha Aglo	1
RT RUBI_CRISTAL_44X23,7 CF PX ESC	SC242442	J0075856686	41,554	Pronto	Derrogado	0,5	DENSIDADES ELEAVDAS - derrogadas por PA	[SOC] Stock Escolha Aglo	1
RT RUBI_CRISTAL_44X23,7 CF PX ESC	SC242442	J0075856686	41,554	Pronto	Derrogado	0,5	RETIFICADO EM 45X23,85 / COMPRIMENTOS ELEAVDOS + DENSIDADES ELEAVDAS - DERROGADO POR PA	[SOC] Stock Escolha Aglo	1
RT RUBI_CRISTAL_44X23,7 CF PX ESC	SC242442	J0075858978	21,891	Pronto	Derrogado	0,5	DENSIDADES ELEAVDAS - derrogadas por PA	[SOC] Stock Escolha Aglo	1
RT RUBI_CRISTAL_44X23,7 CF PX ESC	SC242442	J0075858978	21,891	Pronto	Derrogado	0,5	RETIFICADO EM 45X23,85 / COMPRIMENTOS ELEAVDOS +	[SOC] Stock Escolha Aglo	1
Total	757,009								26

CLASSE	CALIBRE
Selecionar tudo	Selecionar tudo
AGL_RCT	36X23,5
CDR - EXT	38X23,55
CDR - EXT CF	40X27
CDR - MOLD	41X28,5
CDR - MOLD CF	42X26,5
DELTA	42X27
RUBI	42X28,8
RUBI CRISTAL	44X23,55
SPI	45X27
	45X28,8
	47X29,5

SC	SY
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