Politecnico di Torino

Corso di Laurea Magistrale in Ingegneria Gestionale (Engineering and Management)
A.a. 2025/2026
Sessione di Laurea Settembre 2026

How to improve the efficiency and quality of the changeover process for capsuling and wire-hooding machines

The case study of Robino & Galandrino S.p.A.

Relatore:
Prof. Maisano Domenico Augusto Francesco

Candidata:
Giachello Marta

Matricola:
338591

INDEX

1. INTRODUCTION TO THE THESIS 5

2. INTRODUCTION TO THE COMPANY 7

2.1 STRATEGIC POSITIONING IN THE MARKETPLACE 7

2.1.1 INTRODUCTION TO COMPANY'S BUSINESS 7
2.1.2 COMPANY'S STRATEGIC LOCALIZATION 10
2.1.3 PORTER'S DIAMOND MODEL APPLICATION 13
2.1.4 MARKET SEGMENT 16
2.1.5 PRODUCT RANGE 17

2.2 PRODUCTION MODEL 20

2.3 MAKE OR BUY? 23

3. ACTUAL PROCESS STATE MAPPING 25

3.1 PREMISES 25

3.2 COMMERCIAL OFFER PHASE 28

3.2.1 CHANGE PART PROPOSAL 28
3.2.2 POTENTIAL FEASIBILITY STUDY 30

3.3 ORDER PHASE 32

3.3.1 ORDER GENERATION 32
3.3.2 ORDER VALIDATION – INTRODUCTION 33
3.3.3 ORDER VALIDATION – TECHNICAL ANALYSES 36

3.4 CHANGE PART ENGINEERING AND PRODUCTION PHASE 38

3.4.1 CHANGE PART ENGINEERING 38
3.4.2 CHANGE PART PRODUCTION 41

3.5 AFTER SALES ASSISTANCE PHASE 42

3.6 OVERALL PROCESS VIEW 45

3.7 IDEF0 DIAGRAMS 45

4. CRITICALITY ANALYSIS 47

4.1 KEY CRITICALITIES 47

4.2 STRUCTURING OF EMERGED CRITICALITIES – *FMECA* DRAFTING 55

5. IMPROVEMENT PROPOSALS 57

5.1 QUALITATIVE AND QUANTITATIVE CONTROLS 57
5.1.1 STUDY RATIONALE 57
5.1.2 PREMISES 58
5.1.3 IMPROVEMENTS 59
5.1.3.1 PART DEPOSITING IN THE WAREHOUSE 60
5.1.3.2 EXTERNAL PRODUCTION SITE MANAGEMENT 61
5.1.3.3 OFFICIAL QUALITY CONTROL POINTS 63
5.1.3.4 STANDARDIZED OFFICIAL ASSEMBLY PROCEDURES 64
5.2 CHANGE PART FORMALIZATION 66
5.2.1 STUDY RATIONALE 66
5.2.2 PREMISES 66
5.2.3 CHANGE PART LIST DRAFTING 67
5.3 ENGINEERING-TO-ORDER LOGIC FOR ALL CHANGE PARTS 67
5.3.1 STUDY RATIONALE 67
5.3.2 ENGINEERING-TO-ORDER PROPOSAL 67
5.4 AI USAGE FOR SAMPLE ANALYSES 68
5.4.1 STUDY RATIONALE 68
5.4.2 PREMISES 68
5.4.3 PRACTICAL AI USAGE TESTS 70
5.4.3.1 BOTTLE ANALYSIS TESTS 71
5.4.3.2 CAPSULE ANALYSIS TESTS 82
5.4.3.3 WIRE-HOOD ANALYSIS TESTS 86
5.4.4 CONCLUSIONS ON AI-BASED ANALYSES 87

6. STRATEGIC IMPORTANCE OF AFTER SALES DEPARTMENT 89
6.1 AFTER SALES INTERVENTION IN COMMERCIAL OFFER PHASE 89
6.1.1 ADVANTAGES 90
6.1.2 RISKS 92
6.1.3 PROS AND CONS BALANCE 93
6.1.4 RACI MATRIX 95
6.2 AFTER SALES IMPACT ON OVERALL COMPANY'S PERFORMANCE 96

7. FINAL CONCLUSIONS 101

APPENDIX 103

BIBLIOGRAPHY 143

RINGRAZIAMENTI 145

1. INTRODUCTION TO THE THESIS

This thesis emerged out of the curricular internship that I carried out at the company *Robino & Galandrino S.p.A,* in the period between March and May 2026. This firm operates in the sector of bottle packaging, specifically producing some capsuling and wire-hooding machines for their secondary-closing. In order to better understand production process dynamics, thus the reasons behind this dissertation, it is useful to specify that machinery production is always order-based, given the high degree of product customization the company offers, which is required by the necessity of specifically adapting machine characteristics to the type of products the customer needs to work on it. Therefore, the whole process can be classified of being of "pull" type: it is always activated by the end-user, specifically aligning it to his quantitative and qualitative standards, which are determined based on an accurate analysis of his needs and wants.

Considering this context and the particular importance covered by customer's requirements, the aim of this experience, thus of this dissertation, was that of optimizing change part process flow. Indeed, change parts define all those components that vary as a function of the products to be worked on the machinery (bottles, capsules, wire-hoods) and that need to be customized depending on their specifications, so that to guarantee that they will be optimally processed. This can well explain why improving their handling procedure can ultimately favour company's operations, by closely optimizing its ability to meet customer's desires.

Particularly, the choice to dedicate this activity to these components' management flow was based on a clear company's need, that emerged during the preliminary meetings, when the activities which this internship experience should have been dedicated to were investigated. In this context, the necessity arose to define a model for improving and optimizing prototyping and changeover process of capsuling and wire-hooding machinery. Indeed, it was pointed out that, also when selling machines that are highly standardized in their mechanical structure, it is anyway necessary to activate an engineering-to-order phase, specifically concerning change part adaptation. Considering this aspect, the criticality lied in the fact that their management process had not been adequately mapped, formalized and analysed in its limits and potentialities yet, causing that it often revealed to be out of control.

Therefore, the experience that is being described in this report was aimed at overcoming these limitations to streamline the just mentioned process and improve firm's overall performance, thus customer retention in the long-term. This purpose was achieved by mapping this process actual state, so that to favour the clear identification of its main problematic aspects and propose some improvement actions to solve them.

Specifically, this thesis is organized into seven chapters, including the one that here figures. The central macro-sections are four, from the third to the sixth, and address the macro-objectives of this dissertation. Detailly, they cover four main macro-areas:

- **Description of actual changeover process state, in relation to both capsuling and wire-hooding machines:** the third chapter focuses on the analysis of change part process informative, physical and documental flows, starting from commercial offer up to the finished machine, to guarantee that contract specifications are translated into precise technical parameters and to ensure that engineering and production are correctly carried out, depending on customer's samples. Therefore, this macro-paragraph first addresses the mapping procedure of change part process current state, by qualitatively describing it, so that to obtain

its picture at present, then formalizing and schematizing the emerged peculiarities through the means of flowcharts and IDEF0 diagrams;

- **Analysis of the emerged key criticalities:** the fourth chapter first carries out a qualitative description of the most relevant criticalities emerged from the "as-is" process mapping, then formalizing them through the construction of a *FMECA* table and its related *Pareto Chart* and *Risk Matrix*;
- **Improvement proposals to optimize change part process flow:** the fifth chapter addresses the need to maximize the existing synergies among commercial, technical and production areas, with the aim of improving the engineering-to-order process and overcoming its currently problematic aspects. In this sense, some improvement actions were proposed, so that to define a specific approach, which starts from the mapping activity of the actual process state and of the currently used engineering devices, then integrating them with some proposals of new technologies and quality/quantity control points, that allow to improve sample-machine matching;
- **Analysis of the strategic role played by the After Sales department:** the sixth chapter deals with the investigation of the importance covered by the After Sales Assistance department. Indeed, while analysing change part process current state, it emerged that this one plays a fundamental role in change part sale and management and generally represents a key functional unit within the company, in terms of profitability and customer retention in the long run. Thus, the need arose to specifically analyse its importance, with the aim of finally proposing some improvement actions to streamline and optimize its daily and long-term operations.

These four sections, that constitute the body of this dissertation, are enriched by two additional chapters, the second and the seventh ones. Particularly, they concern:

- **Introduction to the company:** this second chapter is aimed at introducing company's history and evolution, then analysing how it strategically positions in the marketplace and how it is structured;
- **Final conclusions:** the last chapter was introduced to pull the wires of this thesis, focusing on the work that has already been accomplished and on the one that has been suggested to the company to achieve some key future improvements.

2. INTRODUCTION TO THE COMPANY

2.1 STRATEGIC POSITIONING IN THE MARKETPLACE

2.1.1 INTRODUCTION TO COMPANY'S BUSINESS

The company *Robino & Galandrino S.p.A*. was born in 1964 in Canelli, hometown of traditional Italian Spumante wine, where it has been able to grow up together with the biggest national winemaking businesses, sharing with them the progressive and continuous development of its own industrial activity. Then, firm's success is the result of a constant interaction with the key actors in the winemaking industry, that have stimulated a continuous evolution of all proposed technological solutions. In struggling to provide increasingly efficient answers to customer's requirements, the company has been able to undergo significant development over time, turning its business into a reference point for bottling and packaging sector (*Robino & Galandrino, 2021)*.

In particular, the firm is specialized in "secondary-closing" of any bottle type and serves all most important wineries in the world, other than breweries, distilleries, oil mills and vinegar factories, adopting a well-developed commercial network, not only in Italy, but mainly abroad, where it earns 70% of its profit. Specifically, the company engineers, produces and assembles a complete portfolio of wire-hooding and capsuling machines, which fit well the distribution and closing operations of both metallic wire-hoods, typical of Spumante wine, and metallic or plastic capsules, used for still or sparkling wines and for all other product types (*Robino & Galandrino, 2021)*.

The business is part of a group of companies, which operate in the field of equipment production and soft-drink packaging and are coordinated by *Immobiliare G.T. S.r.l.* Specifically, the group is made up of three companies (*Robino & Galandrino, 2021)*:

- *Robino & Galandrino* → its capsuling and wire-hooding machines will be detailly depicted in paragraph 2.1.5;
- *Cames* → its production includes some historic products, such as washer-dryers (see Figure 1) and orienters (consider Figures 3 and 4), integrated by a variety of new products, among which there are air-conditioners for filled bottles (an example is depicted in Figure 2) and feeders of caps made of cork and synthetic materials (to be found in Figures 3 and 4);

Figures 1-2 From the left to the right, example of a washer-dryer (LR model) and of an air-conditioner (IR model) (Robino & Galandrino)





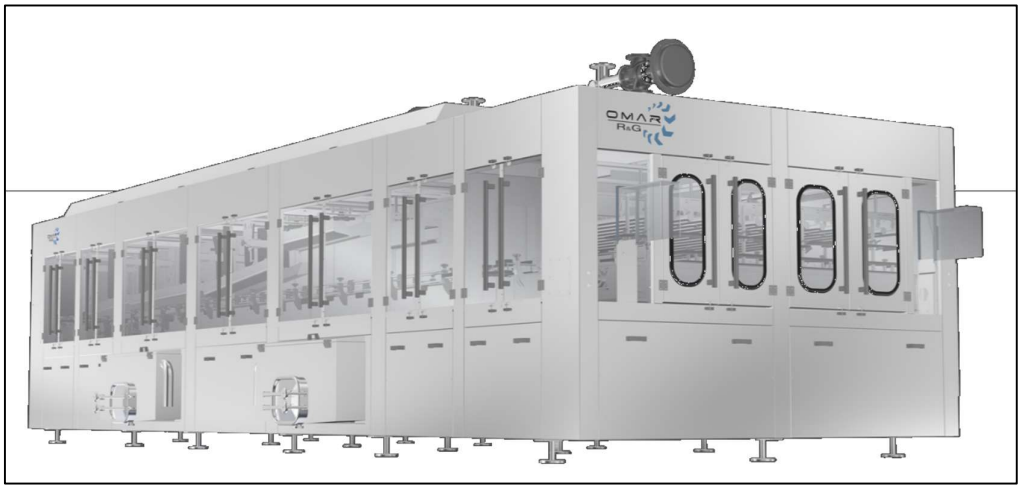
Figures 3-4 Example of feeders/orienters: from the left to the right, ALX-0 and P-ZERO models *(Robino & Galandrino)*



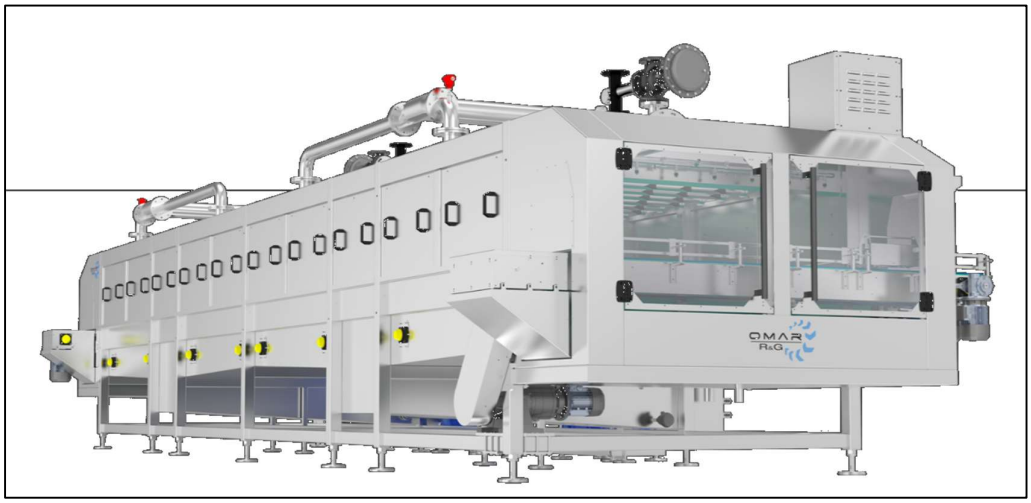
- *Omar R&G* → it is specialized in producing monoblock equipment for capsule distribution and closing (see Figure 5), bottle warming/cooling tunnels (some examples are provided in Figures 6 and 7), washer-dryers for bottle exterior body (to be found in Figures 8 and 9) and linear and semi-rotary labelling machines (see Figures 10 and 11).

Figure 5 Example of a monoblock equipment for capsule distribution and closing: Gemini model *(Robino & Galandrino)*

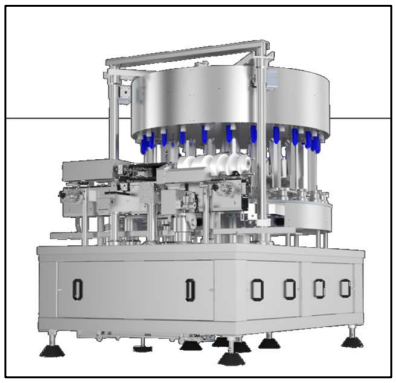




Figures 6-7 Example of bottle warming/cooling tunnels: HTD model (above) and HM one (below) ***(Robino & Galandrino)***

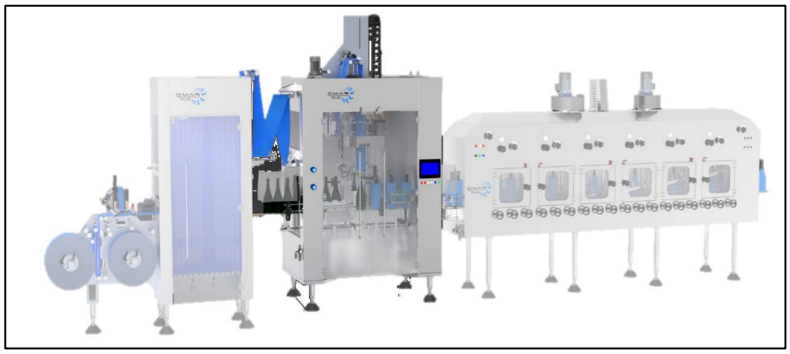


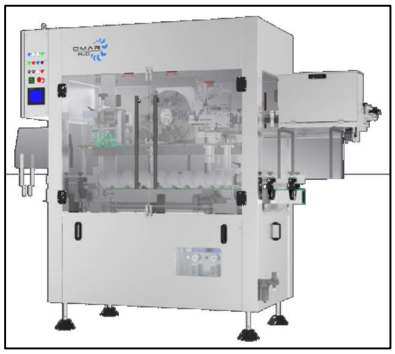
Figures 8-9 Example of washer-dryers: from the left to the right, ASC00R and ASC00X models ***(Robino & Galandrino)***





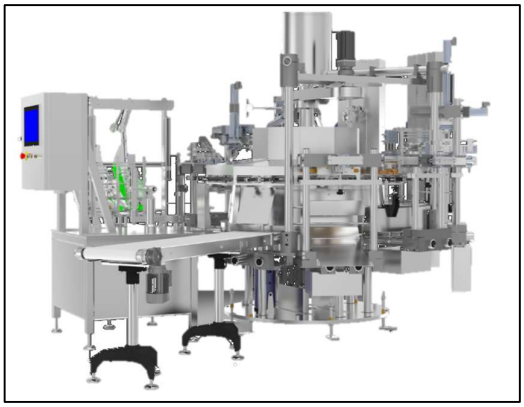
Figures 10-11 Example of labelling machines: from the left to the right, a sleever and a promotional cone dispenser *(Robino & Galandrino)*

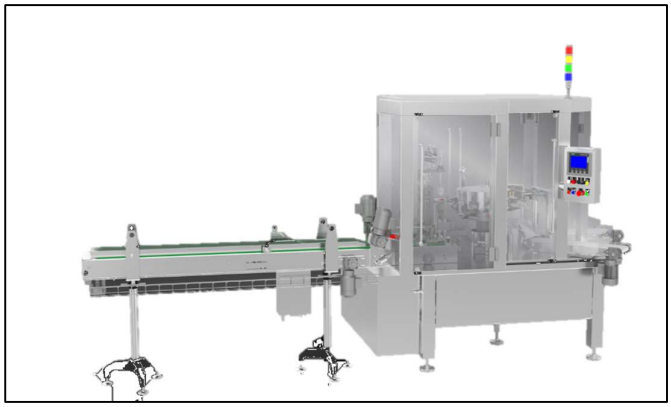




To these companies, it needs to be added a special division of *Robino & Galandrino* itself, called *TS Packaging Division*, which engineers and produces machinery and accessories for flexible packaging market sector, also satisfying the demand of some firms operating in pharmaceutical, cosmetics and pet-food areas. This division offers some advanced packaging solutions, consisting of complete lines of machines suitable for forming and filling several different flexible packs (some examples are given in Figures 12 and 13). These ones can be flat, stand-up or specially shaped and can be either pre-formed or formed by the machine itself, starting from a coil and processing it through FFS (Form, Fill & Seal) technology *(Robino & Galandrino, 2021)*.

Figures 12-13 Example of machines for flexible packaging (Robino & Galandrino)





2.1.2 COMPANY'S STRATEGIC LOCALIZATION

Analysing company's performance over time, it was clear that this had not only been determined by its internal resources. Another key factor is represented by the industrial and competitive context of the specific geographical area where the group operates. This one turns out to be a regional economic system, within which there is a strong and resilient cluster of highly specialised factories, operating in the winemaking industry. Over the decades, they have been able to support this specific market segment and make it flourish, taking advantage of the structural characteristics of the geographical context where they were born *(Lavina & Billella, 2024)*.

Basically, firms in Canelli's area (see Figure 14) rose to meet some specific needs of this zone and then grew up with it, increasingly specialising and creating a unique industrial district, which embodies this sector's know-how in the hands of few companies, highly specialised in bottling, labelling and secondary-closing operations. These ones, being all placed within this cluster, have built over time a highly unified industrial network, coordinating and integrating themselves in the

realization of complete lines, that handle bottles from the start up to the end of their productive flow. This is achieved through a mix of experience, competence and knowledge, that gathered its strength from the peculiarities of the area where it was built, therefore turning out to be unique and hardly imitable in other geographical locations *(Lavina & Billella, 2024)*.



Figure 14 Some of the companies within Canelli's winemaking cluster, producing equipment for packaging sector (Lavina & Billella, 2024)



Everything started in 1865, when Canelli witnessed the creation of the first Italian sparkling wine. From this first step, an extended network of wineries was born; these ones progressively enlarged and became so internationally relevant that they are now considered to be the symbol of the winemaking industry in the world. Because of this rapid growth and economic dynamism, they started needing increasingly sophisticated machinery, that could be able to adequately support and optimize their development and expansion, with the purpose of improving their efficiency, while supporting their growing offer and increased turnover. Therefore, their need of a diversified supply chain favoured the birth of a set of satellite industries, being closely connected to the phases and requirements of the winemaking production. Starting from this, the bottling and secondary-closing equipment industry was born: it began with small workshops and then gradually developed into large and modern factories, that progressively faced an increasing demand and then exponentially enlarged, until this industrial hub turned into "one of the most authentic and winning examples of Made in Italy" *(Lavina & Billella, 2024)*.

So, the success of the firms that belong to this industrial district has its roots in the way they have grown up over time. Particularly, this history of progress and innovation got started when the first relevant company in this sector – OMECC - was founded; this one achieved some excellent results, thus inspiring and favouring the birth of several other factories. Over the years, they have experienced some peculiar growth and expansion, until they turned into some entrepreneurial excellences of great success and finally became world leaders in the industry. This was favoured by the fact that the administration was entitled to some technicians that used to work at OMECC, who had been trained and raised by skilled and capable entrepreneurs. Therefore, they succeeded in making the most out of the experience they had acquired in such a dynamic and cutting-edge context, so that to manage their own businesses in the same way and drive them to the success and notoriety they still have nowadays. Indeed, after this cluster's emergence, Canelli was not only labelled as the hometown of Spumante wine, but it transformed into a proper high-tech hub; this contributed to enhance this area's economic development and affected its social structure organization *(Lavina & Billella, 2024)*.

Therefore, Canelli's industrial phenomenon drew its strength from its own geographical position, being located at an ideal crossing point, which combines agriculture, industry and proximity to large markets. Indeed, it was first encouraged by the "perfect marriage" between agriculture and industry, with cellars requiring new machinery to improve their production and then actually satisfying this demand in the supply of local firms. Concerning this aspect, it is interesting to point out that initially there was no real bottling equipment industry and many operations were still carried on manually.

Therefore, when the demand for this product type started emerging and then expanding, the faster and easier choice was that of being supplied by French and German companies. However, at that time, the diversity in producers' and consumers' languages was an issue, particularly when it came to managing and maintaining the equipment over time. Thus, a new demand arose: that of qualified firms in the industry, that could operate locally to deal with this need and satisfy it *(Lavina & Billella, 2024)*.

In other words, the industrial development of this area and the expansion of this specific market segment were simply natural, since they were inspired and guided by the geographical position where this growth got started. This brought to a singular example of production approaching its initial product: this phenomenon stood as a peculiar kind of industrial progress, where the agricultural areas were not abandoned, but became the target for some significant and sustainable investments. Indeed, entrepreneurs and workforce moved towards Canelli and its surroundings, so that to set up and carry out their businesses close to that raw material - the vineyard - which had initially led to the birth of this industrial segment. Moreover, this cluster could benefit and get strengthened by the fact that workers had grown up among vineyards and cellars, thus they represented the best resource this ecosystem could ever have, in terms of ability, knowledge and desire to make their land flourish. This finally produced a concentrate of highly qualified and skilled resources, which have enriched this area and still nowadays constitute one of its greatest legacies (*Lavina & Billella, 2024).*

To more deeply eviscerate this concept, it can be stated that it was because of these singular characteristics, being specifically related to the geographical position of the wine technology industry, that this industrial system became a unique one around the globe. Moreover, this inimitable set of skills and knowledge was carried on across generations and progressively drew some increasing strength from the clan of interconnected companies that has emerged over time *(Lavina & Billella, 2024)*. Indeed, it is known that clans of companies and long-term relationships among them play a crucial role in affecting market forces, particularly when dealing with small sectors. This is caused by the fact that, within a clan, the same firms experience some common traditions and are linked by continuity in market transactions, which ultimately create commonality of purposes, values and beliefs, thus strengthening trust among the parties *(Grant R.M., 2021).* Furthermore, over the years, this sector has shown some hardly replicable experience and autonomy, so that it finally succeeded in reaching some clever productive and commercial diversification. Indeed, all products and services offered by these businesses were initially only intended for the winemaking sector; nowadays, on the contrary, they have finally entered some other fields in the packaging industry, from those entitled to mineral water and soft drinks, up to the ones operating in pharmaceutical and cosmetic areas *(Lavina & Billella, 2024)*.

To sum up, the kind of continuous success and growth that still distinguish this district's firms, including *Robino & Galandrino* group, lies in their common denominator: the ability to undertake some constant R&D projects to innovate their processes and products, with the aim of supporting this industrial system's progress, but keeping its roots in the area of great excellence where it was first established. In fact, this territory represents a proper supply chain, which is able to follow a bottle of wine from the raw material – the grapes – up to the finished product, namely the wine packaged in bottles with label, cork, capsule and neckband *(Lavina & Billella, 2024)*.

In conclusion, an analysis can be conducted to understand how this cluster's excellence can be preserved and further developed in the years to come. Basically, the challenge for the future lies in firms' ability to further invest in continuous dialogue and cooperation. Indeed, this approach has already revealed to be a precious one, helping them overcoming the fragmentation of production and

the excessive entrepreneurial individualism. Detailly, the key factor to have this area increasingly prosper requires making some investments and taking on some special actions, with these ones including the entire market sector: not just winemaking equipment, but also satellite industries, agribusinesses and wine tourism. Indeed, it is interesting to highlight that the companies which manufacture winemaking equipment for cellars, specifically producing some machines to deal with bottling, closures, labels and generally packaging, account for a combined turnover of around 800 million Euro. However, if the perimeter is extended to include those who sell wine, foodservice and hospitality and wine tourism, the total value rises to 3.5 billion Euro. This approach offers a more holistic perception, which allows the entire area, not just a single segment, to coordinate and unitedly move towards success and development. Therefore, unity is the starting point to achieve some common goals, which can in turn guarantee this cluster's resilience in the long-term. Specifically, this requires companies identifying some collective needs and implementing some projects being able to benefit the whole territory. Starting from this, these businesses can then take advantage of their history and leverage on the legacy left by previous generations, finally adopting the same forward-looking spirit that first transformed this area into the birthplace of a completely new industrial segment. By doing so, this one will be able to increasingly grow and exploit its full technological, professional and personal potential and excellence *(Lavina & Billella, 2024).*

2.1.3 PORTER'S DIAMOND MODEL APPLICATION

The just proposed description has been formalized and structured into *Porter's Diamond* analytic model. This approach allows to strategically evaluate the competitive ability of a local economic system to make a specific industrial segment flourish and prosper, by identifying the structural conditions that determine the success of the considered industry within the given geographical context. Basically, it allows to understand why some specific firm types can be successful in a precise territory, in order to finally point out what needs to be done to maximize their competitivity in the long run *(Grant R.M., 2021) (Rudello)*.

This model is organized into four main elements and two external variables, which are graphically placed to form the vertexes of a diamond; by simply analysing how they reciprocally interact, these ones allow to explain the reasons why a specific geographical area is able to generate and maintain a competitive advantage in a specific industrial sector. Specifically, since these factors are not isolated, but they influence one another, it possible to measure the strength of a local competitive system as a function of connection density and quality among these variables *(Rudello).*

In the following, they are listed and detailly depicted, specifically adapting them to the details of Canelli's competitive market, where *Robino & Galandrino* is placed and operates.

Factor conditions: they are related to company's positioning in a geographical area rich of relevant infrastructure and/or highly qualified personnel, thus including the set of material and immaterial resources that the territory possesses and upon which the industrial production stays *(Grant R.M., 2021) (Rudello)*. They can be divided into two main categories:

- **Base factors**: they include natural resources, geographical position, weather, water availability, demographics, historical traditions, cultural identity and generic workforce. Therefore, they constitute a set of elements, which are hardly replicable in the short term and strongly related to local territory's geophysical features *(Rudello).* Specifically in relation to the currently analysed scenario, there is an element, which was of primary importance for the creation of this area's unique industrial ecosystem: the physical proximity of raw material, wine producers and equipment suppliers, respectively the vineyards, the cellars and the

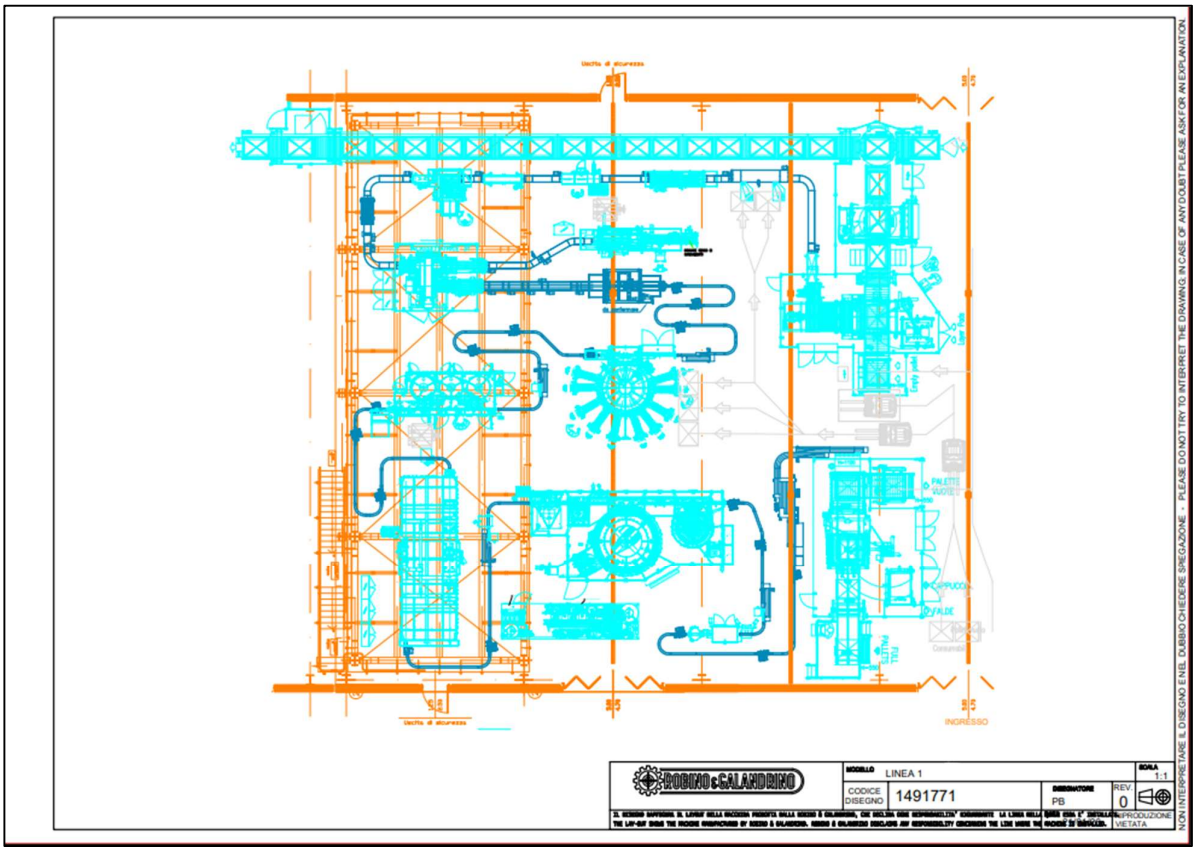
mechanical engineering companies of the winemaking industry. Moreover, another relevant factor lies in the historical and cultural background of this area, that, being the birthplace of Italian sparkling wine and having always been devoted to oenology and winemaking, has progressively developed a real wine culture; this was the factor that led to the birth of a proper technical and cultural wine infrastructure, committed to sparkling wine production and packaging. Finally, it can be said that this segment has always taken advantage of its own workforce, traditionally raised and trained by men and women, who had grown up among vineyards and cellars and thus had a strong commitment to take on any challenges and uncertainties, as well as to provide their own knowledge in this field, with the aim of making their land famous all over the world *(Lavina & Billella, 2024)*.

- **Advanced factors:** they include highly specialised human capital, technical know-how, logistic and digital infrastructure, educational system, universities and research and innovation ecosystems *(Rudello).* With respect to the area that is being analysed, it is rich of personnel with ultra-specialised engineering know-how. This one has been carried on across generations and supported by a network of technical institutes, as well as educational and research centres of national importance, such as *Politecnico di Torino*. These ones allow for a constant flow of mechatronic and automation competences, while also supporting companies in developing technologically advanced innovative solutions *(Robino & Galandrino, 2021).*

Demand conditions: they are referred to as a sophisticated and proactive domestic market, showing a rapidly increasing demand, which represents a natural driving force for innovation. Indeed, demanding and sophisticated consumers put some major pressure on local firms, forcing them to continuously improve and progress, so that to able to satisfy a fragmented and differentiated demand within high value-added business models (*Grant R.M., 2021) (Rudello)*. In this way, companies are ultimately required to accelerate the introduction of new products and innovative solutions, invest in product customization and advanced research and guarantee high quality services and standards *(Rudello*). All this perfectly depicts what happened to Canelli's area, thus to *Robino & Galandrino*, which had to conform to sophisticated and demanding customers, who had a strong need for high-precision packaging equipment for luxury products. In this way, they forced the company to constantly and rapidly innovate, improving product quality and efficiency, thus attaining to the requirements of both local and foreign markets, ultimately getting ready to successfully face global competition *(Robino & Galandrino, 2021).*

Relating and supporting industries: this factor refers to some well-developed industrial ecosystems, which are characterized by a strong cooperation among complementary firms, with this one facilitating the development of such a competitive advantage to increase overall productivity, reduce coordination costs and favour technological contamination and innovation. Basically, this element refers to the concept of cluster, namely a geographical concentration of interconnected businesses, specialised suppliers, technological partners, educational and advanced research institutes *(Rudello)*. Even in the case of this aspect, Canelli's area represents an emblematic example. Indeed, a strong synergy and cooperation exists among firms at play in the winemaking industry, which often integrate their machinery in entire production lines, where bottles are fully handled by local companies *(Lavina & Billella, 2024)*. An example of a wine bottle packaging line is provided in Figure 15.

Figure 15 Example of a wine bottle packaging line, including machinery for both primary and secondary closing *(Robino & Galandrino)*



Moreover, this area's firms are supported by a strong, rich and specialised network of local suppliers, such as mechanical component, valve and cork businesses. In relation to these last ones, it is interesting to notice that, at the beginning of the last century, big wineries used to buy their corks from foreign suppliers. However, over time, it became common knowledge that proximity to production sites allows to speed up delivery time, build closer relationships with customers and develop a deeper understanding of the market where they operate. Thus, in Canelli's area, some important local factories were founded, which were specifically intended to deal with this market segment *(Lavina & Billella, 2024)*. It is no chance that even *Robino & Galandrino*'s IT service management, from a managerial and organizational perspective, is entitled to local IT companies, such as *Sistemi Tre S.r.l.* for ERP supply. This choice was made because these firms were born in this same geographical area; therefore, they closely know its needs, which they can optimally satisfy, allowing for product high scalability and customization *(Robino & Galandrino, 2021)*. As it has already been introduced in the paragraph above, this supply chain's synergy can be further enhanced by touristic and cultural markets, which have been able to strengthen local brands, especially after this territory's recognition as part of the *UNESCO* heritage; this has attracted investments and international visibility, which indirectly benefit even winemaking industry *(Lavina & Billella, 2024)*.

Structure, strategy and rivalry: this factor concerns the way companies are managed, which is assessed by analysing local entrepreneurial network in terms of managerial culture and internal competitive dynamic intensity, considering domestic rivalry as a force that drives firms to continuously improve. Referring to the structure, the focus is on adopted organizational and governance models *(Rudello)*. Concerning this, it needs to be noticed that *Robino & Galandrino*

handles a global value chain, which possesses a high degree of vertical integration, that will be later deepened in paragraph 2.3. Moreover, it has incorporated within the group some niche industries, namely highly specialised PMI, dealing with single process phases, such as Omar R&G and Cames, producing equipment for air conditioning, warming, washing and drying operations (*Robino & Galandrino)*. The second factor, strategy, deals with the way companies look at the market and face it, namely their risk exposure, change culture and propensity to make some long-term investments *(Rudello)*. About this, the previously mentioned shared managerial attitude among companies in Canelli's area favours strategic alignment and local industrial system's strengthening *(Lavina & Billella, 2024)*. In relation to the third aspect, rivalry, the secondary-closing market is not characterized by great dynamism, since there are some strong barriers to entry, which consolidate the already acquired competitive advantage. However, given the reduced number of reference companies in this market segment and considering the high degree of required product customization, it is of no doubt that a fierce competition exists among the few firms operating in the sector, which struggle in trying to satisfy these requests; indeed, they are aware of the fact that, if this did not occur, customers would simply go to a direct competitor, inducing their related companies to do the same. This approach generates some pressures with a clear positive advantage, since they stimulate continuous improvement and operating efficiency and accelerate innovation cycles; this was the case of *Robino & Galandrino,* where this condition made the company develop that diversified and multi-varied know-how, which is now its core strength *(Robino & Galandrino, 2021)*.

Government: this word refers to those public policies, such as subsidies, education and antitrust laws, which can favour or hinder the four factors considered in the model *(Grant R.M., 2021)*. In this case, official recognition of Canelli's winemaking industrial district contributes to provide these companies with access to regional and national calls, funding and training programs *(Robino & Galandrino, 2021)*.

Chance: it is intended as unpredictable events, such as radical scientific innovations, wars, natural disasters or pandemics, that can shuffle all factors at play *(Grant R.M., 2021)*. Considering the winemaking industry, after having slowed down in 2020/2021, as a consequence of the worldwide health situation due to COVID-19 pandemics, it has revitalized, confirming the already previously growing trends and recording a boom in the field of Spumante wine, which favoured the demand for those technologies, where Canelli's firms are world leaders *(Robino & Galandrino, 2021).*

The graph representing *Porter's Diamond* model applied to Canelli's industrial hub is reported in the Appendix, in the section dedicated to paragraph 2.1.3, specifically in Figure 51.

2.1.4 MARKET SEGMENT

Focusing on the company which this discussion is devoted to, namely *Robino & Galandrino*, it needs to be more closely analysed, considering the market segment where it is placed, specifically entitled to secondary-closing equipment producers. This one is characterized by a competitive system, which is not particularly dynamic, in terms of number of players. Indeed, this sector represents a niche within the broader wine market, where just few and highly specialised companies operate, competing for the global portfolio of customers *(Robino & Galandrino, 2021)*.

This scenario is due to some high barriers to entry, which discourage new companies to compete in the market, concentrating its whole demand in the hands of an extremely limited number of producers. Among these barriers, one of the key ones is represented by equipment high technical and technological complexity, tightened by consistent structural investments required to start production activity. Other ones concern the need for proprietary technologies to be able to satisfy any productive

requests and the importance of detaining that knowledge and ability that the company has historically developed in this sector, obtaining a diversified and multidisciplinary know-how, which is at the heart of the so-called "learning economies" *(Robino & Galandrino, 2021)*. Indeed, companies that have already gathered a strong experience in a specific market segment are deemed to better and closely know it, meaning that they can optimally serve it at lower costs, with these ones decreasing as accumulated production volumes – thus accumulated experience – increase *(Grant R.M., 2021)*. Nevertheless, it has already been pointed out that a high degree of internal rivalry exists among the few companies operating in this context. This peculiarity acts by imposing some positive pressure, aimed at research and development activities, which are fundamental to reach and then maintain customers, by offering some increasingly innovative and efficient solutions *(Robino & Galandrino, 2021)*.

Within this market segment, one of the major sources of sales and profits for the company currently lies in the field of wine producers, which is often characterized by an obsolete machine pool, thus allowing for a constant and stable demand for machinery and equipment of any type and dimension. Generally, the expected evolution in the wine market is oriented towards a contraction in the number of players but still showing an increase in production volumes. Consequently, the possibility arises for the company to consolidate its ones in this area in the years to come, without excluding the chance of even acquiring some further quotas, particularly because of the decreasing trend in the number of competitors *(Robino & Galandrino, 2021)*.

Referring to the just depicted market, it is the segment dedicated to Champagne and Spumante which is of particular interest, since it shows some rapidly growing trends, thanks to its strong need for constant packaging renewal. In fact, the quantitative increase in sold volumes leads to bottling line users requesting some increased productive capacity, both directly, through an enhancement in machine production performances, and indirectly, through a reduction in the occupied spaces and a boost in After Sales service efficiency and effectiveness. In conclusion, this global boom has acted and is still acting as a strong external accelerator, leading to a burst in the demand for those technologies specifically intended for Champagne and Spumante wine and offering some new market opportunities to the firm *(Robino & Galandrino, 2021).*

2.1.5 PRODUCT RANGE

Considering this company's product range, it has already been stated that its production, which highly depends on market requests and wants, has growingly specialised over time. Indeed, notable technical and financial resources have been invested to cope with customer's specific needs. In this sense, an intense research and innovation work has constantly been under the way, leading to the development of the actual product range, which consists in nine different equipment types. This innovative capacity, articulated according to a "customer-driven" logic, is the result of the kind of market where the company operates, which is continuously evolving, thus necessarily requiring high qualitative standards and increasingly innovative solutions, to be technologically advanced and tailored upon customer's requests *(Robino & Galandrino, 2021)*.

Moreover, the firm is aimed at consolidating its market positioning and strengthening its leadership in the medium-long run, as well as at keeping up with industrial context's most recent evolutionary roadmaps. That is why it has engaged into a continuous development process, through which it wants to rationalise its production and improve man-machine interface. This proposal consists in engineering new modular and flexible productive platforms; these ones will allow to design increasingly user-friendly facilities, both in terms of electro-mechanical and software and interface components, and to considerably increase productive performances, investing into processing speed,

reliability, result reproducibility and reduction of setup times following a format change *(Robino & Galandrino, 2021)*.

Furthermore, the firm is intended to implement a step change in facing energy consumption patterns and production environmental impact. The purpose is that of introducing some innovative solutions to reach energy savings and environmental impact reduction, together with equipment simplified handling and end-of-life recovery and disposal of its related components. In this view of sustainability, which is perfectly aligned with the requirements of Industry 5.0 industrial paradigm, the company also aims at improving efficiency in terms of employed resources, reducing their consumption, by progressively abandoning low-performance mechanical parts and implementing some major advancements in thermic and acoustic isolation systems, to be achieved thanks to the usage of some innovative materials *(Robino & Galandrino, 2021)* (*R. Stark, G. Seliger & J. Bonvoisin, 2017)*.

Currently, facility portfolio covers the whole productivity range required by the market, in relation to processing speed, which varies from 500 to 40.000 bottles/hour, and concerning system integration, ranging from semi-automatic solutions for small handcrafted productions up to large and fully automated industrial facilities *(Robino & Galandrino, 2021)*.

Wire-hooding machines are organized into two families: “Vittoria” set (see Figure 16), made up of single-head automatic machines for wire-hood distribution and binding on Spumante wine bottles at working speed from 1.500 to 3.000 bottles/hour; “Record” set (see Figure 17), consisting in rotary automatic machines for production processes working from 4.000 to 25.000 bottles/hour *(Robino & Galandrino, 2021)*.

Figures 16-17 From the left to the right: example of a “Vittoria” wire-hooder and of a “Record” one *(Robino & Galandrino)*



Capsuling machine variety is broader and arranged depending on capsule type to be processed (see Figure 18) and on processing speed (low - up to 3.000 bottles/hour, medium - from 3.000 to 8.000 bottles/hour - or high - from 8.000 to 40.000 bottles/hour). Specifically, according to the first parameter, machine specifications are defined based on the type of bottled product, which can be still, sparkling or Spumante, and on capsule material, which can be a heat-shrinkable one (PET, PVC) or polylaminate/tin *(Robino & Galandrino, 2021) (Robino & Galandrino S.p.A)*.

Figure 18 Example of different capsule types. From the left to the right: PVC/PET capsules for heat-shrinking, polylaminate/tin ones for roll forming and large ones specific for Spumante wine



Concerning capsuling machine variations in relation to capsule types, most relevant differences lie in the kind of necessary processing heads, which are often interchangeable on the same machine model, so that this one can potentially work any capsule type, by just changing the required heads. Specifically, when focusing on Spumante wine, capsuling process is structured into two key operations, namely the making of the four folds and their subsequent straightening; this type of capsuling process occurs trough single-stage or bi-stage pneumatic heads, respectively of lower and higher quality, and almost always requires optical centring, in order to perfectly align the capsule itself. When considering the other products, if capsule material is a heat-shrinkable one, capsuling process always requires thermal heads; otherwise, if capsule is made of polylaminate/tin, rolling heads are employed *(Robino & Galandrino, 2021) (Robino & Galandrino S.p.A)*. Some examples of capsuling machines are provided in Figures 19-23.

Figures 19-20 From the left to the right: Fenix and Miniblock capsuling machines, for small-medium productions and with universal application, fitting polylaminate, PET, PVC capsules and the ones specific for Spumante wine (Robino & Galandrino)

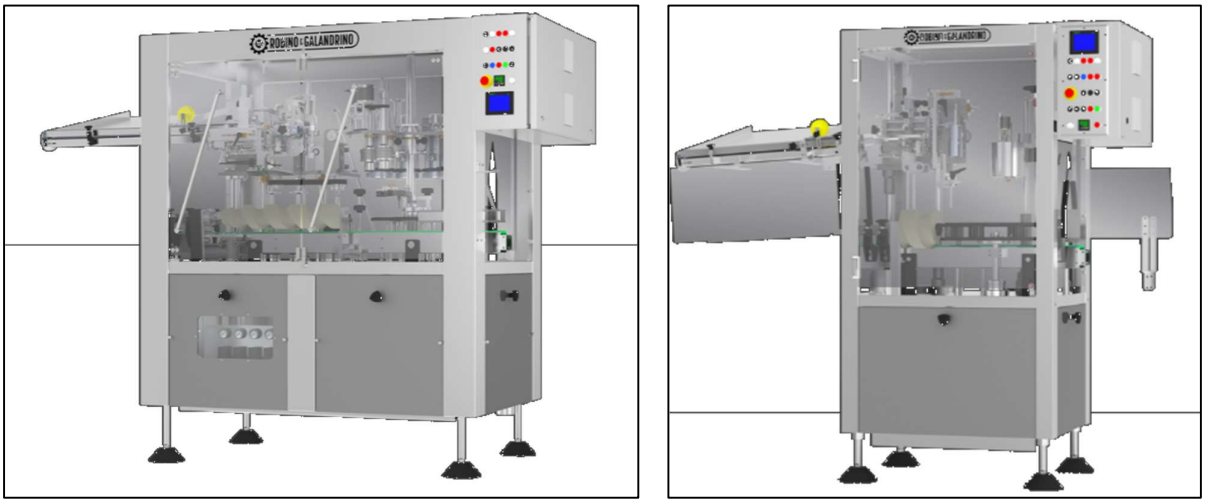


Figure 21 Single-stage capsuling machine, fitting all capsule types and allowing to condensate folding and smoothing of Spumante large ones in a single stage (Robino & Galandrino)

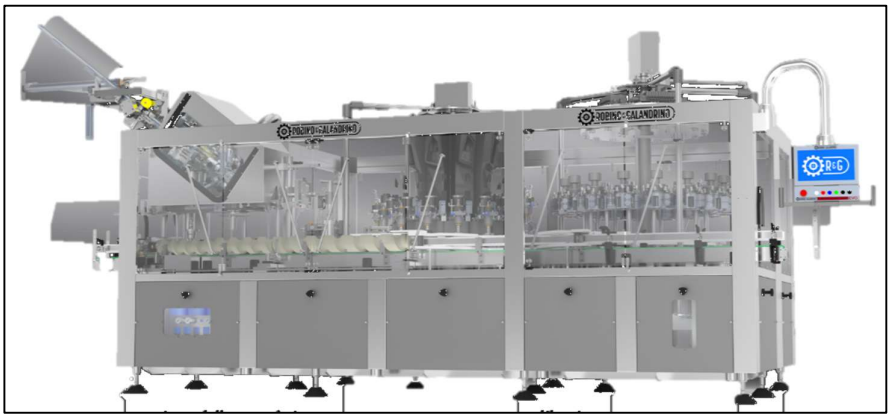
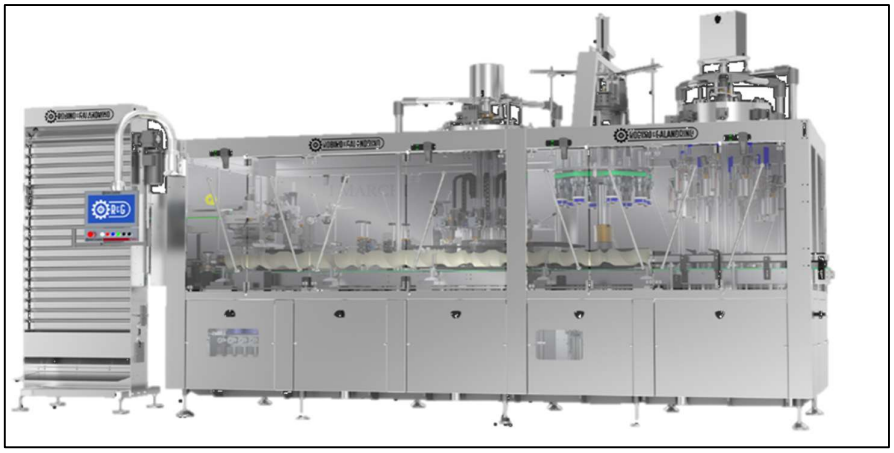


Figure 22 Zenith capsuling machine, for medium-high productions and fitting Spumante large capsules only (Robino & Galandrino)



Figure 23 Poker capsuling machine, for medium-high productions and with universal application, fitting all capsule types (Robino & Galandrino)



2.2 PRODUCTION MODEL

In order to clearly understand how the company operates, it is fundamental to clarify the type of production model it has adopted. As it has already been stated in chapter 1, machine construction is always order-based, meaning that the procedural iter does not start until an actual request is received from the customer; therefore, the whole process can be classified of being of "pull" type.

Even though machinery is always engineered from scratch, upon the receipt of a specific order from the customer, the degree of its customization changes in time, depending on the analysed production stage. Indeed, it is important to notice that, generally, machine's mechanical structure essentially remains invariant; what changes is related to bottle, capsule and wire-hood change parts, namely all those components that follow these elements along their route on the machinery and that need to be customized, depending on their specifications. Detailly, they are defined as parts which are thought to be interchanged whenever a format change turns out to be necessary. Particularly, the word "format change" is specifically used to refer to the variation of all those components that concern the handling, containment and processing of the products to be worked on the machinery (bottles, capsules and wire-hoods), with the first ones being selected depending on their measures and features.

Concerning this point, to better clarify it, it needs to be explained that Mechanical Technical Office, which plays a role of primary importance, is practically organized into two macro-areas, which are submitted to two separate production flows, showing two different logics and reflecting the above depicted distinction.

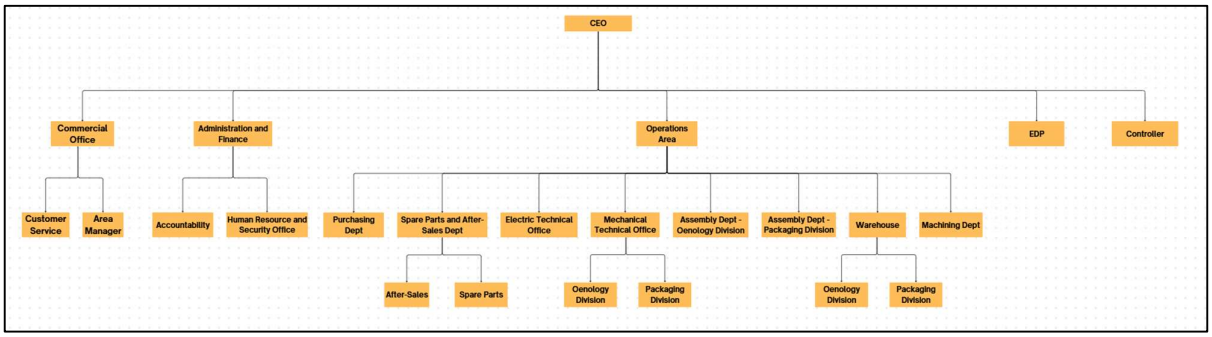
At first, during the initial engineering steps, which are activated immediately after an order issuance, machine's mechanical components, like gearboxes and columns, start to be designed, in such a way to determine their shape and ensure that all standard formats can be processed. Basically, the designer himself draws machine's mechanical structure, without adapting his drawings to a specific bottle/capsule/wire-hood format, but simply conforming them with the standard range, within which workability must always be guaranteed.

After that, once samples of the products to be worked on the machine are verified, it is the time of the designers being specifically entitled to the engineering of all those dedicated components, which vary as a function of customer's product formats, namely change parts. To be precise, they commit themselves to the parametric engineering of bottle change parts only; indeed, these ones are always produced starting from scratch, specifically for each order, following an engineering-to-order logic. On the contrary, capsule/wire-hood change parts follow a more standardized iter, which shows an assembly-to-order logic: their production is sample-based, meaning that a generic code is assigned to each of them, but this one does not represent the finished part, rather a pre-worked element, common to several different orders, to be chosen and paired according to capsule/wire-hood format and to be later worked depending on its specifications.

To synthetically describe the whole production process, the order receipt from the customer is the starting point. The subsequent production flow is then organized and managed in a coordinated way by different functional units (depicted in Figure 24). Everything starts from Commercial Office, which deals with the offer phase and finalizes machine sale. Then, a crucial step of technical validation is performed by Sample Room/Mechanical Technical Office, considering that the first is a special division embodied within the second; this function is entitled to sample verification to officially validate the order, by testing machine adequacy with customer's bottle, capsule and wire-hood formats. After that, Mechanical Technical Office and Electric Technical Office, provided with several CAD/CAM workstations, oversee customized machine engineering, defining its specifications according to customer's desires and requirements. Then, it is the time of Purchasing Department, which makes sure that all required components and materials are properly made available for production, so that to allow it to go on in the operational units. These ones are: Machining Department, equipped with CNC workstations, lathes and milling machines, to cope with mechanical component production; Electric/Electronic Department, aimed at producing machine's electric and electronic components; Assembly Department, organized into two sub-units, namely

Assembly for medium-speed machinery and Assembly for high-speed machinery. Final Testing Department certifies machine quality, before delivering it and terminating the production flow. Finally, After Sales Department is concerned with spare parts, customer service and support and continuous relationships with him over time. Moreover, it is interesting to specify that R&D function is integrated in Technical Offices themselves and then extended to all productive units, since the company internally engineers, produces and tests all innovative solutions. Therefore, it is correct to state that R&D structure perfectly coincides with company's productive one, whose resources are both allocated to ordinary production activities and to continuous innovation ones, even though to different and varying extents *(Robino & Galandrino, 2021).*

Figure 24 Organizational structure: it is of functional type (Robino & Galandrino, 2021)



The just depicted functional units have been formalized into an official organizational chart, depicted in Figure 24. Analysing this one in its details, company's structure turned out to be of functional type. Indeed, each functional unit is directly controlled and administered by a manager, specifically in charge of it. This structure has the advantage of favouring operational efficiency, encouraging specialization and promoting learning and capability building. However, it also has some major disadvantages: individuals are mainly focused on their function's matters and scope, without considering order's broader ends, thus leading to some key criticalities in terms of workflow coordination *(Grant R.M., 2021)*. This is a major issue because high communication and cooperation need to be achieved, not only among different units, but also among different companies. This scenario occurs because of the high degree of machine customization, process complexity and the fact that company's equipment needs to be integrated in a line, specifically adapting it to other machines, also produced by different companies.

Because of these issues, after having carefully analysed firm's market positioning with functional managers, it has become a priority to point out that direct supervision may not be enough anymore. So, the idea of adopting a matrix structure has emerged as a possible way to face the above depicted limitations. In this way, the company would be able to introduce a dual structure, according to which functional managers, in charge of vertical operations management, could be supported by a project manager, strategically entitled to generally and horizontally manage whole orders. This would favour flexibility maximization, thus making the company always able to quickly respond to order changes and attain to its final objectives *(Alberto De Marco, 2018)*.

To sum up, the usefulness of adopting this kind of organizational structure lies in the fact that the company operates in a complex and dynamic environment, where customers ask for a high degree of product changes, progressive adaptation and customization. Particularly, when dealing with the construction of large and extended lines, made up by machines produced by several different companies, which need to be perfectly synchronized, a matrix structure organized by functional departments could be of great advantage. Indeed, this is the best organizational model for medium-

sized companies with multiple products, since it allows for flexible sharing of human resources across orders and for functional and product skill development, while also supporting complex decisions and frequent changes in this kind of unstable environment, highly dependent on customer's expectations and requirements *(Grant R.M., 2021).*

2.3 MAKE OR BUY?

To conclude the analysis of company's strategic positioning, when it comes to Make or Buy decisions, it can be said that the first approach is generally preferred, favouring an in-house production of most components. External suppliers are only provided with the demand for hardware, secondary parts and type of processes that do not entail any distinctive core competences and that the company is not able to perform internally, such as laser cutting, painting and, generally, all thermal and surface treatments, which require some chemical processing.

This choice is a necessary consequence of the high degree of customization and asset-specificity characterizing the production flow of company's machines, which requires specialized and detailed processes, closely defined as a function of customer's needs and wants. Moreover, the necessity for the company to develop and manufacture its products in-house emerges because of their complexity, accompanied by the difficulty in codifying their specifications and, consequently, in finding suppliers that are competent enough to deal with these aspects *(Grant R.M., 2021).*

Indeed, given process complexity and its dependence on customer's demand, the greatest advantage of internally producing most components is represented by the fact that superior coordination of production flows and webs of inputs and outputs can be attained, ensuring an adequate control of design attributes, in terms of timing, sequence and technical fit. Moreover, this choice turns out to be particularly useful to deal with the exchange of tacit knowledge, which is a distinctive aspect of the process and of the kind of managerial approach adopted in the area where the company operates. Furthermore, in-house production also allows for resource control and protection, especially with respect to intellectual property, thus avoiding leakage of private information, thanks to the company retaining its technological solutions. Over the years, some particularly relevant innovations have been protected through patents, but these ones are known to be less effective for process technologies. In fact, since they are less subject to public scrutiny, patents would only counter-productively disclose some of their unique details; that is why, in this case, secrecy, attained by internally retaining critical component production, reveals to be much more effective *(Grant R.M., 2021).*

Internally owning the proprietary technologies required to cope with productive needs is then a significant and powerful strength. Besides protecting company's industrial secrets, this also allows it to be quick in responding to any potential problems emerging in final testing phase and in speeding up the procedures to adapt any new formats to an already produced machinery. This point is fundamental in terms of firm's strategic positioning in the market sector where it operates. Indeed, several companies were born over time, with the aim of producing the kind of change parts required by the type of machinery this group offers; for this reason, some cases occurred, where customers asked for change parts that were not supplied by *Robino & Galandrino*. This ultimately happened because of firm's waiting times, that were thought to be too long for the increasingly demanding modern market. Therefore, in front of such a critical scenario, in the context of Make or Buy choices, it was a winning decision that of internalizing most production processes, with a particular focus on those technologies having shorter lead times. This allowed to reduce waiting times and stay competitive in the marketplace, retaining customers with a combination of high quality, delivered in short response times.

The choices that have been investigated above are entitled to Purchasing Department, which needs to decide whether to produce the necessary components in-house or to outsource them to external suppliers. To describe its role, it is fundamental to specify that it is not only entitled to purchasing operations, but also, in a broader perspective, to procurement ones, thus to the whole supply chain management. Indeed, there is a substantial difference between these two concepts, which still maintain two different roots, despite being highly integrated and interconnected *(SAP, 2024)*.

In a broader sense, procurement refers to the whole strategic, cyclic and continuous planning and management process, consisting of supplier selection, contract negotiation, reminders in case of delay and continuous relationship management and being centred on progressive adaptation to company's needs and market conditions, which constantly evolve. Thus, it is a task with a broader meaning, which is aimed at maximizing company's value over time, so that to get a real competitive advantage, which is sustainable in the long-term, because it is based not only on cost savings, but also on product quality improvement, service delivery quality, customer satisfaction and supplier innovation. On the contrary, when considering purchasing, the word "simply" refers to a specific and quicker phase within the whole supply chain, specifically dealing with good and service booking and receipt, quality controls and payment accuracy, then finishing once goods and services are received and suppliers are paid. Therefore, it is a tactic, operational and transactional phase, aimed at cost control, budget compliance and on-time delivery, so that to ensure efficient and effective purchasing operations *(SAP, 2024)*.

To detailly describe the activities performed by this functional unit, the following ones can be listed:

- Purchasing of in-catalogue components, such as electronic and technical parts;
- Purchasing of raw materials, through generation of some production orders that commit Raw Material Warehouse;
- Technical drawing analysis, specifically for each order, in such a way to identify any mechanical and carpentry components, that need to be dedicatedly bought for each considered machinery;
- In case of generic components, for which some stock is always kept in the Warehouse, performance of a below-stock analysis to identify the EOQ (Economic Order Quantity) and the re-order point, according to which a replenishment is needed, so that to keep the optimal amount of stock in the Warehouse, at the minimum costs, and avoid any disruptions;
- Quantitative and/or qualitative non-conformity analysis, upon component receipt.

The need for the type of activities described above is determined by the kind of production model that the company has, which is a mixed one. Indeed, more generic components, which are common to all machine types, independently of order specifications, are produced with a make-to-stock logic, always keeping some of them in the Warehouse. On the contrary, as already described before, capsule and wire-hood change parts follow an assembly-to-order logic: some pre-worked parts are preliminarily machined; then, according to sample format, the most appropriate one is paired and, only upon sample receipt, it is finally detailly worked, specifically in relation to its measures, so that to get the finished workpiece. Differently, an engineering-to-order logic is adopted for bottle change parts, which are always designed and produced from scratch, waiting for bottle samples to be received, in such a way for these components to be immediately adapted to order characteristics.

3. ACTUAL PROCESS STATE MAPPING

3.1 PREMISES

As it has already been stated in chapter 1, this thesis, emerged out of my internship experience, is mainly aimed at addressing a clear company's need, thus the one connected to the definition of a model for improving and optimizing prototyping and changeover process of capsuling and wire-hooding machines.

Therefore, the first activity which was carried out to reach these purposes consisted in a mapping procedure of the actual process state. Indeed, lack of a formalized, complete and structured definition of this process key steps and peculiarities made it necessary to progressively act to draw them up, by implementing a bottom-up approach. In this sense, some detailed descriptions offered by the staff were first collected; then, starting from this base, a progressively wider picture was extracted, little by little.

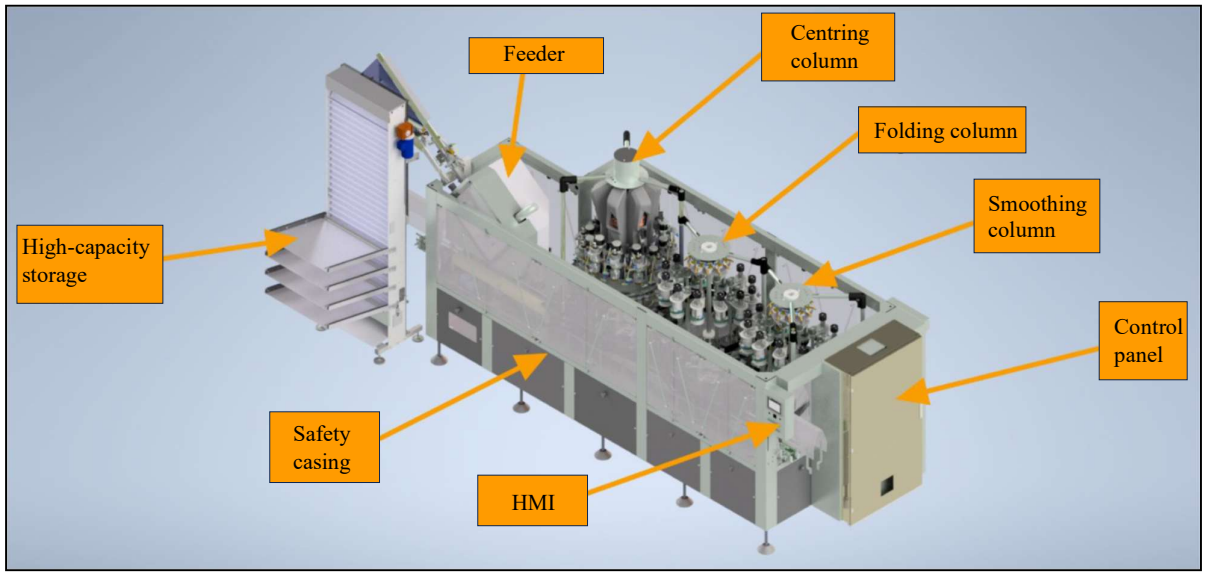
Detailly, the first step consisted in interviewing the employees entitled to each of the stages that constitute this process, in such a way to qualitatively depict its key phases, by focusing on the details and features highlighted by their descriptions. After that, the flowcharts specifically linked to each step were gradually defined to facilitate the visualization and comprehension of the sequence of practical actions and decisions. These ones were then integrated by other two comprehensive flowcharts, considering the process as a whole: one related to the overall decision-making procedure to be implemented in dealing with this process and the other one dedicated to the flow of documents that accompany these steps, so that to guarantee their future traceability. Finally, process general structural hierarchy was finalized, by adopting the logics of IDEF0 diagrams.

DESCRIPTION OF ROBINO & GALANDRINO'S MACHINERY FUNCTIONING

In order to make process subsequent description as clear and comprehensible as possible, this paragraph contains a synthetic analysis of wire-hooding and capsuling machinery functioning. This will clarify, right from the beginning, which are the change part types that these machines need to process customer's products at best, and it will also describe these components' key functionalities, by following bottle processing route on the machinery itself.

Concerning this aspect, it was the most complex machine type that was chosen for explanatory purposes. This one is the capsuling machine committed to work Spumante wine bottles, since it is comprehensive of all component and process types (an example is provided in Figure 25). For this description to be as clear and exhaustive as possible, it will be distinguished between those change parts, which are common to any machine type, and those other ones, which vary, on the contrary, as a function of product and process kind.

Figure 25 Structure of a capsuling machine, committed to Spumante bottle processing (Robino & Galandrino S.p.A., 2021)

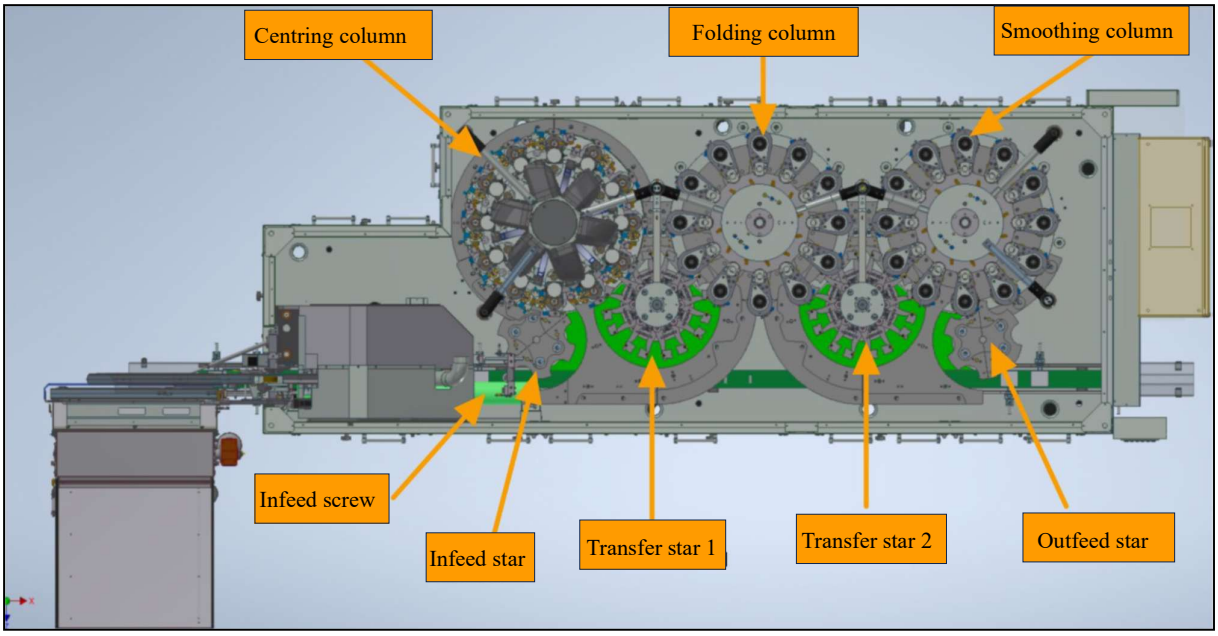


To detailly analyse this machinery functioning, it initially receives some entering already tapped bottles, through a conveyor belt, which brings them to feeder's station. Simultaneously, an automatic vertical storage supplies the feeder itself with some capsules. Specifically, this unit is organized into two sub-stations:

- the first one takes the capsule out of the storage and singularizes it;
- the second one deposits the capsule on bottleneck, after having centred it.

To better specify what happens in this first stage, the bottle moves forward along an infeed constant-speed screw. This one has a double purpose: to provide the rectilinear motion and to put the bottle at pace with the subsequent processing columns. At the end of the infeed screw, a component named infeed star transforms the rectilinear motion into a circular one to prepare the bottle for the first processing column, namely the centring one. After that, there is the second processing column, where the folding process takes place; this one occurs through some dedicated heads, which are pneumatically activated and which make the four folds, typical of the large capsules used for Spumante wine. At the end of this phase, a transfer star is used to move the bottle from the folding column to the smoothing one. This last process is carried out through a pneumatic head, which is aimed at plastically deforming the capsule, by making it adhere to the bottleneck, in such a way to obtain the best aesthetic result. At the end of this process, the outfeed star transports the bottle on the conveyor belt, thus completing the process flow *(Robino & Galandrino S.p.A, 2021)*. To better visualize all these change part types, a dedicated representation can be found in Figure 26.

Figure 26 Most important change parts to adequately process customer's products on the machinery (Robino & Galandrino S.p.A, 2021)



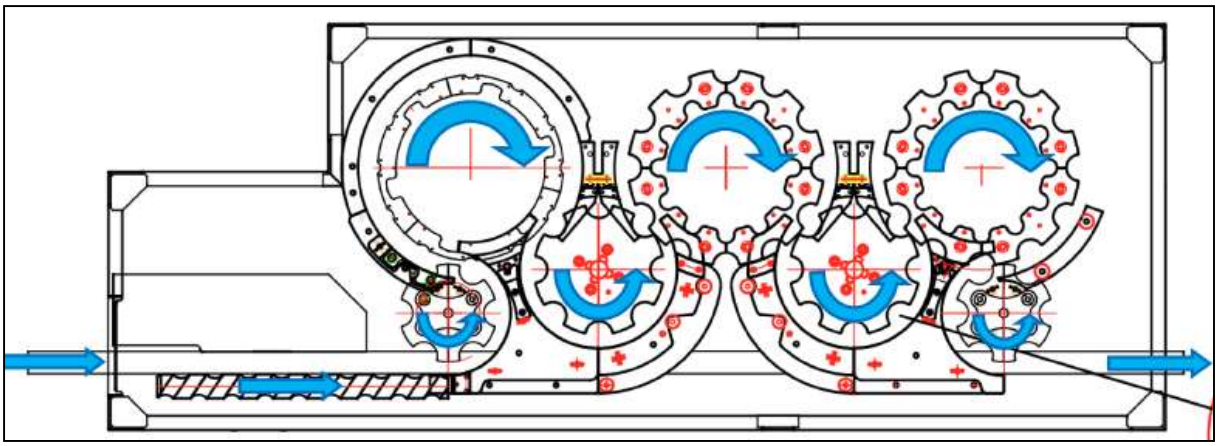
To better clarify the just depicted working process, it needs to be specified that it is carried out in a closely similar way also when handling wire-hoods and capsules for other product types, following the same processing logic. Indeed, machine's structure basically remains the same, even though some substantial differences must be considered, in relation to processing columns *(Robino & Galandrino S.p.A, 2021)*.

First, centring column is not always there. Indeed, when dealing with Spumante wine, considering that the large capsules can fit a medallion and/or some specific writing to be aligned with the label, this column is quite always introduced, requiring a dedicated group for optical centring, through a photocell or a UV spot. On the contrary, when considering the other product types, if the capsule does not show any symbols to be specifically oriented or when handling wire-hoods, this column may be omitted *(Robino & Galandrino S.p.A, 2021)*.

Furthermore, processing columns vary as a function of the product type to be worked (capsule or wire-hood) and, when considering capsules, depending on their material. Concerning the distribution phase, in case of a wire-hooder, the feeder is of course equipped with wire-hood distribution heads *(Robino & Galandrino S.p.A, 2021)*. On the other hand, considering the processing phase as such, as it has already been stated in section 2.1.5, processing columns can be of different types. Beyond the just described ones, for Spumante wine, which are equipped with pneumatic heads, it needs to be specified that, if capsule material is a thermo-shrinkable one, the processing column is provided with thermal heads, whereas, if the capsule is made of polylaminate/tin, processing occurs through rolling heads *(Robino & Galandrino S.p.A)*. Of course, when considering a wire-hooder, processing column is equipped with wire-hooding heads *(Robino & Galandrino S.p.A, 2021)*.

An example of the general route that any bottle follows on the machinery is provided in Figure 27.

Figure 27 Bottle flow on the machinery (Robino & Galandrino S.p.A, 2021)



3.2 COMMERCIAL OFFER PHASE

Going back to this thesis' purpose, sample and change part management process can now definitely be described. Basically, it begins with customer's request, which can originate from a dealer or from the client himself. At that point, a commercial offer is defined, specifying all key elements: machine type, manufacturing process where it will be employed, customer's production rate (measured in bottles/hour) and types of bottles, capsules and wire-hoods to be processed on the machine, because of which the client actually needs to buy it.

In relation to this first phase, in this section, the base-case scenario will be analysed, namely the one where the commercial offer is handled and finalized by Commercial Office. However, some cases may occur, where it is the After Sales Department which deals with this step. This is a process anomaly, to be carefully analysed, faced and improved; therefore, it will be neglected for the moment and then properly considered in a dedicated section, at the end of this document, to be found as chapter 6.

Concerning this phase, depending on how much the customer is informed about the company and the machine types it produces, it is possible that he already sends bottle technical drawings at this step. Furthermore, based on bottle, capsule and wire-hood formats, the sales manager considers the necessity of any potential format changes in the required change parts, so that to preliminarily define their type and total number.

Once the offer has been finalized, it is sent to the customer and saved in a file, that contains the progression of all commercial offers linked to the three realities that make up the group (*Robino & Galandrino, Omar R&G and Cames*). By doing so, it will be stored on the PC of the sales manager who proposed it and then copied on a server, specific and internal to Commercial Office, making it shared and available within this functional unit.

3.2.1 CHANGE PART PROPOSAL

Considering what has just been described, a key step in defining the commercial offer is represented by the proposal of the main change parts to be used, depending on the considered machine and samples. This one then needs to be verified and approved by Mechanical Technical Office during the validation step of the arisen order.

With the aim of depicting what is meant by “change parts”, they will be briefly mentioned in this paragraph, while they will be more detailly described, with their related drawings, in section 5.2, about change part formalization and structuring.

CAPSULES

In this case, the most important change parts are: processing heads with their related components, distribution bells, centring cones, spherical caps for bottleneck shape, single-stage dowels and ejectors.

WIRE-HOODS

Here, the most relevant change parts turn out to be related to distribution and wire-hooding heads, including their related components. Concerning the necessity to have different change parts for different wire-hood formats, this is usually lower if compared to that for the capsules, due to more sporadic and less significant dimensional differences.

BOTTLES

The crucial change parts needed to process bottles, that must already be defined during the offer phase, are: infeed screws, stars (infeed, central, outfeed, centring bottleneck, transfer), spacers, drawer sides and conveyors. They can either be standard or dedicated, depending on bottle format and their dimensional characteristics. In addition, when dealing with conical bottles, the difference between inferior and superior diameters requires evaluating the usage of partial change parts, to be separately and distinctively applied, particularly when considering stars.

With the aim of determining the number and type of change parts required to process all identified formats, starting from the technical drawings sent by the customer or from his declarations, the sales manager lists bottle diameters, according to which they will be grouped. Indeed, in case of machines working at reduced speed, the basic rule states that different bottles can share the same change part, only if the nominal difference in their diameters is < 3 mm; rising the working speed, this tolerance increasingly reduces, leading to an increase in the number of dedicated change parts.

As previously introduced, when the customer needs to cope with multiple format changes, the sales manager is required to make it clear that different change parts need to be replaced, in such a way to well accommodate them. This causes an increase in machine downtimes; thus, to solve this criticality and minimize lead time, the sales manager can propose to choose all-purpose/standard stars and infeed screws. Indeed, they allow to process different bottle formats without never varying the change parts, clearly if having verified that they are consistent with the ranges allowed by these groups, in relation to the specific machine type. The choice, to be made by the client, needs to be assessed at the functional and economic levels, since the all-purpose components provide an advantage with regard to time, but also to costs, if the cost of each, even though higher in absolute terms, is however lower than the sum of the costs of n dedicated ones. Anyway, this all-purpose equipment can be proposed to the customer only when dealing with conical or cylindrical bottles; on the contrary, it does not fit shaped ones, since they necessarily need some dedicated change parts. Moreover, when considering guides, it is fundamental for the external one to be dedicated, given its critical function of keeping the bottle aligned with the heads.

Finally, in choosing the most appropriate bottle change parts, it is needed to consider whether these will get in touch with a glass, painted or sleevered bottle (see Figure 28). Indeed, this affects the choice of the material to be employed to manufacture these components: in the first case, plastic can

fit well, whereas in the other two, it may be evaluated, in agreement with the customer, to use a softer alternative material, so that to reduce friction.

Figure 28 Example of sleevered bottles



3.2.2 POTENTIAL FEASIBILITY STUDY

In case of dimensions (diameter, height) and/or shapes out of the standard range, a technical, economic and/or timing feasibility study is requested. For instance, when dealing with bottles in standard conditions, considering that the maximum processable height turns out to be around 360 mm, if it is exceeded, it is necessary to evaluate an increase in stroke length, in order to be able to cope with this anomaly. Therefore, this scenario requires the need of sending a technical feasibility analysis request to Technical Offices and evaluating the extra-costs and extra-time that arise because of it; final outcome and extra-charge will ultimately be communicated to the customer *(Robino & Galandrino S.p.A, 2025)*.

To better specify this preliminary process, characterized by the fact that the company does not handle finalised orders, but only commercial offers and their related feasibility requests, all key steps are listed in the following lines:

1. The customer sends physical samples and/or technical drawings;
2. Upon their receipt, the sales manager informs Mechanical Technical Office/Sample Room and defines the purpose of the analysis to be performed on them, by filling out a *MS Word* module, specifically designated for feasibility requests, by sending an email or simply by means of an informal oral communication;
3. A preliminary technical evaluation is conducted, consisting in the following controls, that will be more detailly analysed in paragraph 3.3.3, concerning order validation phase *(Robino & Galandrino S.p.A, 2025)*:
    - Matching analysis between bottle and capsule/wire-hood;
    - Suitability control relative to machine type and setting: compliance with tolerances applied to product specifications, such as diameter, height, etc…;
    - Detection of any potential technical critical issues;

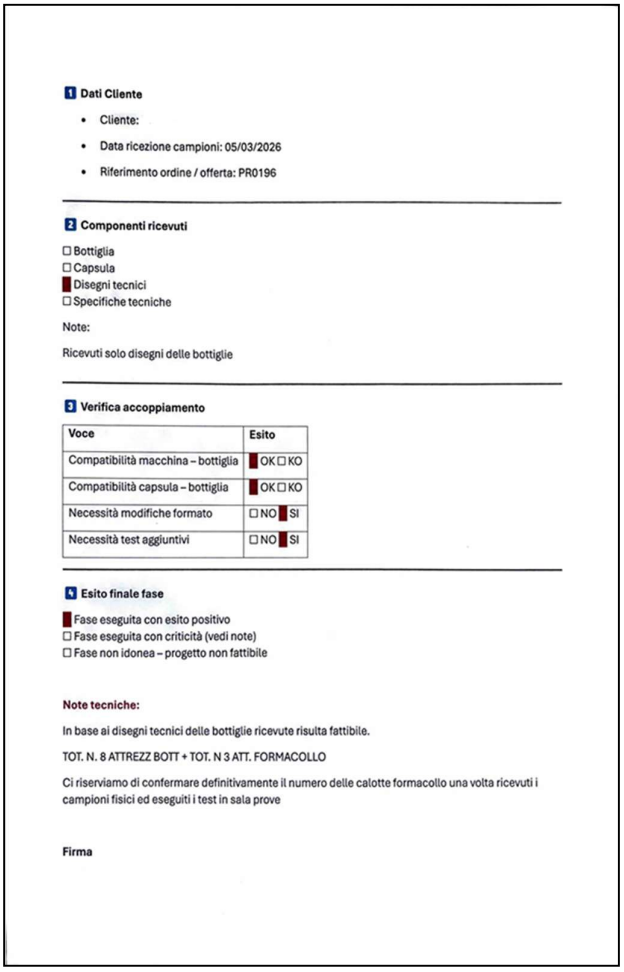
- Concerning capsuling, in case of doubts, possible physical tests in Testing Room.

Technical feasibility result is finally communicated to the sales manager by e-mail in around 1-2 working days *(Robino & Galandrino S.p.A, 2025).*

To analyse this phase's documental flow, it can be pointed out that the company is currently about to introduce a procedure to include all files linked to a specific feasibility study in its PDM, also in relation to the considered change parts. Indeed, in the case of technical analyses for a machine's mechanical components, this is already common practice. This one allows to save the whole accomplished work in the system, also making all related data available to support any future similar orders.

Concerning this procedure, after having received the previously mentioned module/e-mail/oral request from Commercial Office, Mechanical Technical Office/Sample Room creates a project on its PDM *Pro.file*, being specifically entitled to the considered commercial offer. This one is identified through the denomination PR, followed by a progressive number, so that the employees in charge to perform feasibility tests can then populate it. Particularly, they immediately upload the e-mail/module concerning the feasibility request; then, they create other three *MS Word* documents, so that to finally add the feasibility results obtained from the validations performed by Mechanical and Electric Technical Offices and the ones specifically concerning samples (see Figure 29).

Figure 29 Example of sample feasibility validation document (Robino & Galandrino)



1 Dati Cliente

- Cliente:
- Data ricezione campioni: 05/03/2026
- Riferimento ordine / offerta: PR0196

2 Componenti ricevuti

☐ Bottiglia
☐ Capsula
■ Disegni tecnici
☐ Specifiche tecniche

Note:

Ricevuti solo disegni delle bottiglie

3 Verifica accoppiamento

Voce	Esito
Compatibilità macchina – bottiglia	■ OK ☐ KO
Compatibilità capsula – bottiglia	■ OK ☐ KO
Necessità modifiche formato	☐ NO ■ SI
Necessità test aggiuntivi	☐ NO ■ SI

4 Esito finale fase

■ Fase eseguita con esito positivo
☐ Fase eseguita con criticità (vedi note)
☐ Fase non idonea – progetto non fattibile

Note tecniche:

In base ai disegni tecnici delle bottiglie ricevute risulta fattibile.

TOT. N. 8 ATTREZZ BOTT + TOT. N 3 ATT. FORMACOLLO

Ci riserviamo di confermare definitivamente il numero delle calotte formacollo una volta ricevuti i campioni fisici ed eseguiti i test in sala prove

Firma

The flowchart representing the sequence of actions characterizing the offer phase is reported in the Appendix, in the section dedicated to paragraph 3.2, specifically in Figure 52. It was prepared with the aim of clearly and better highlighting the most important steps and favouring the identification of all relevant lacking and problematic elements, which were detected in relation to this procedure, while describing its actual state.

3.3 ORDER PHASE

3.3.1 ORDER GENERATION

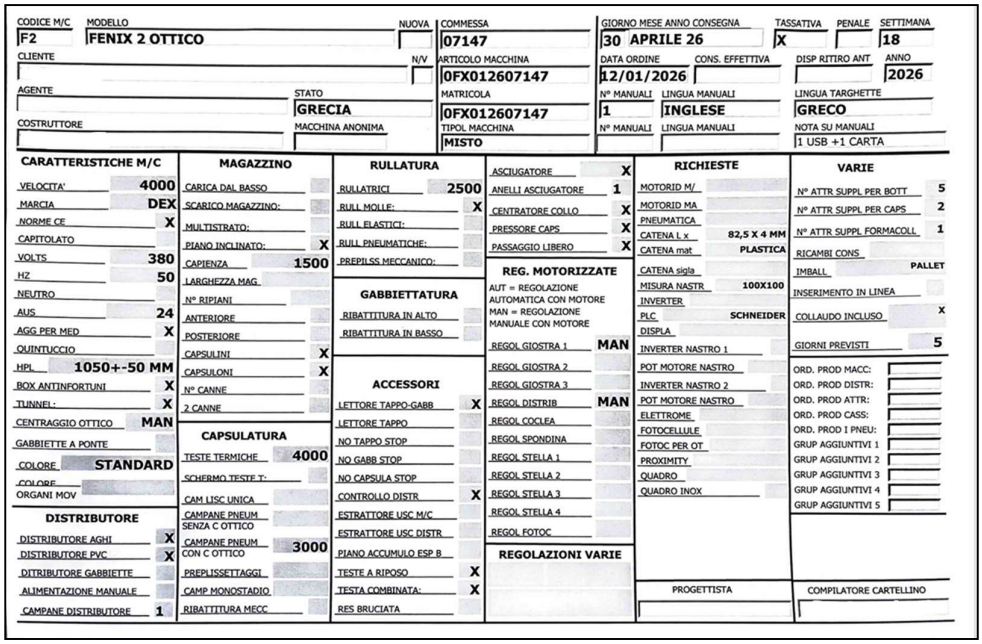
In this phase, upon the receipt of customer's offer acceptance, this one is asked for an advance payment and Commercial Office issues the official order confirmation. Consequently, the order is generated on software *Pro.file*, assigning it a related progressive number and specifying all relevant information concerning the customer who bought the machine. At that point, another key step consists in the definition of the Part Number specifically linked to the order, which is an alpha-numeric and speaking one, since its digits respectively represent: reference company within the group, machine type, month, year and reference order.

To make an example, Part Number 0FX012607147 is made up of the following parts:

- 0 → it shows that machinery is commissioned to *Robino & Galandrino;*
- FX → Fenix machine type;
- 01 → month;
- 26 → year;
- 07147 → reference order.

Moreover, the sales manager defines the so-called *Cartellino* (see Figure 30), a document showing all significant machine specifications and total number and type of change parts, previously proposed to and planned with the customer. This file is both made available on *MS Access* and by paper version.

Figure 30 Cartellino (Robino & Galandrino)



3.3.2 ORDER VALIDATION – INTRODUCTION

Successively, since the offer first and the order that was defined upon it then include some specifications defined with the customer before all, it is necessary to ultimately verify their feasibility, by receiving some samples of the products to be processed. An example of these ones can be found in Figure 31. This step consists in two phases:

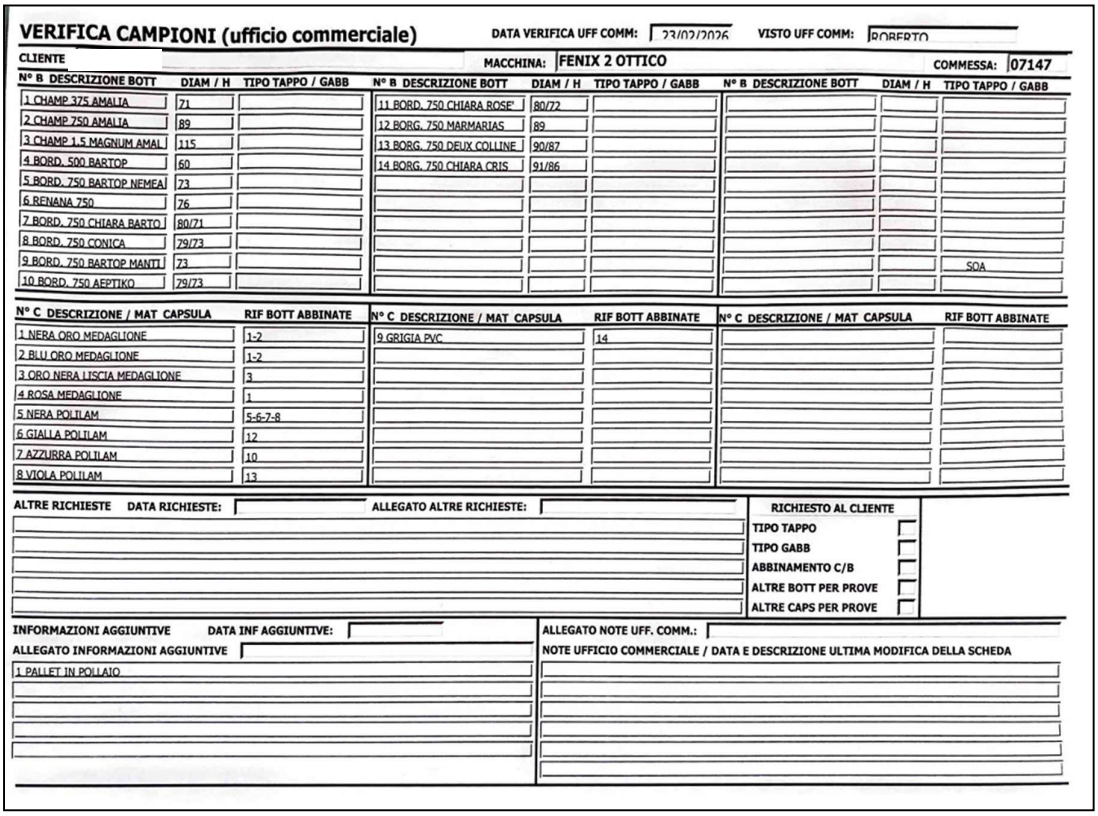
- A first prior sampling step, within a month since order acquisition, during which the customer sends some samples to be tested, in order to go on with the order validation phase;
- A second step, two months before final inspection and supporting the last production phase, during which a second sampling is performed, starting from a larger number of elements, which varies as a function of machine dimensions.

Focusing on the first stage, after having received all necessary samples in the Warehouse, this one fills in a *MS Excel* file, pointing out their receipt. At that time, the boxes are prepared, by inserting one element for each format. This selection phase is particularly sensitive and requires a first visual sorting, so that to be able to distinguish between the various sample types and to make sure that one item for each of them is really picked up.

Figure 31 Example of bottle and capsule samples (Robino & Galandrino)



Once all boxes have been prepared, the sales manager creates a *Sample File* (see Figure 32), the so called “Scheda Campioni” in Italian, where technicians will then introduce all relevant information about them, even though these are not detailed specifications yet. For example, concerning bottles, the following data can be found out: ID number, description, capacity, length and diameter; when considering capsules: ID number, colour and material. Also in this case, the document is made available both on *MS Access* and by paper version.



VERIFICA CAMPIONI (ufficio commerciale) DATA VERIFICA UFF COMM: 23/02/2026 VISTO UFF COMM: ROBERTO

CLIENTE MACCHINA: FENIX 2 OTTICO COMMESSA: 07147

N° B	DESCRIZIONE BOTT	DIAM / H	TIPO TAPPO / GABB
1	CHAMP 375 AMALIA	71	
2	CHAMP 750 AMALIA	89	
3	CHAMP 1,5 MAGNUM AMAL	115	
4	BORD. 500 BARTOP	60	
5	BORD. 750 BARTOP NEMEA	73	
6	RENANA 750	76	
7	BORD. 750 CHIARA BARTO	80/71	
8	BORD. 750 CONICA	79/73	
9	BORD. 750 BARTOP MANTI	73	
10	BORD. 750 AEPTIKO	79/73	
11	BORD. 750 CHIARA ROSE'	80/72	
12	BORG. 750 MARMARIAS	89	
13	BORG. 750 DEUX COLLINE	90/87	
14	BORG. 750 CHIARA CRIS	91/86	
			SOA

N° C	DESCRIZIONE / MAT CAPSULA	RIF BOTT ABBINATE
1	NERA ORO MEDAGLIONE	1-2
2	BLU ORO MEDAGLIONE	1-2
3	ORO NERA LISCIA MEDAGLIONE	3
4	ROSA MEDAGLIONE	1
5	NERA POLILAM	5-6-7-8
6	GIALLA POLILAM	12
7	AZZURRA POLILAM	10
8	VIOLA POLILAM	13
9	GRIGIA PVC	14

ALTRE RICHIESTE DATA RICHIESTE: ALLEGATO ALTRE RICHIESTE:

RICHIESTO AL CLIENTE
TIPO TAPPO
TIPO GABB
ABBINAMENTO C/B
ALTRE BOTT PER PROVE
ALTRE CAPS PER PROVE

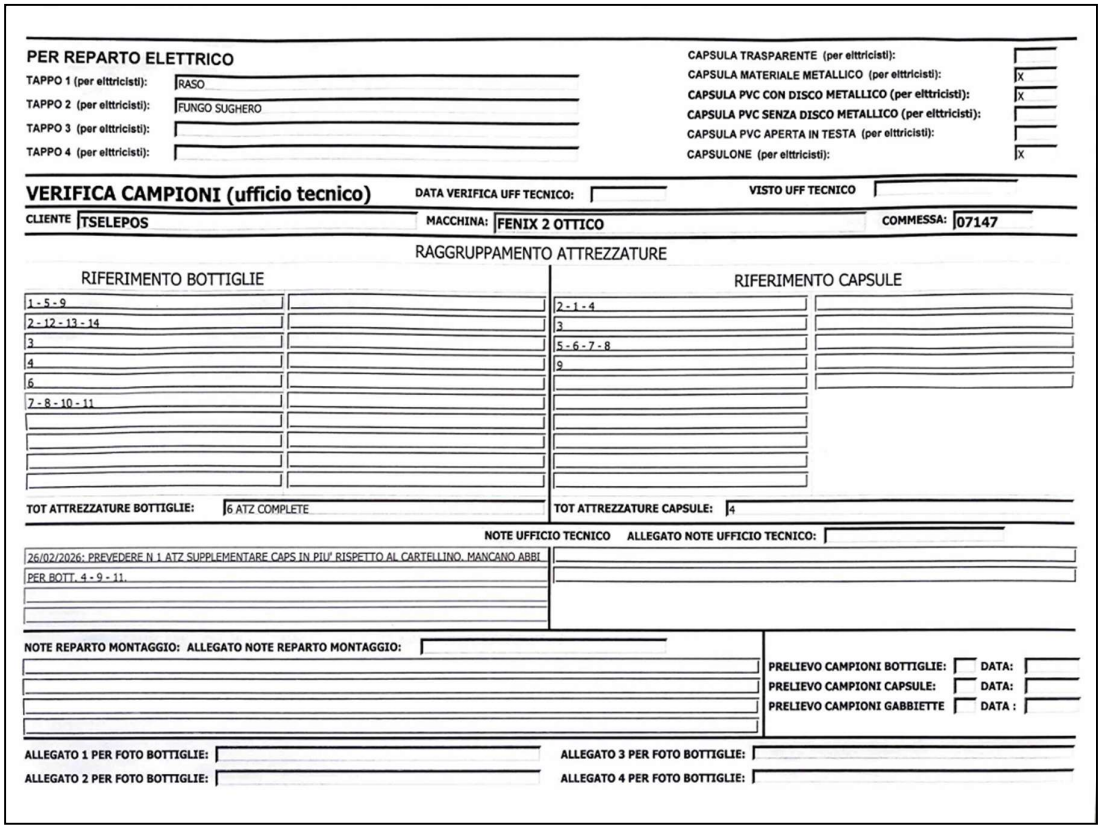
INFORMAZIONI AGGIUNTIVE DATA INF AGGIUNTIVE: ALLEGATO NOTE UFF. COMM.:

ALLEGATO INFORMAZIONI AGGIUNTIVE

1 PALLET IN POLLAIO

NOTE UFFICIO COMMERCIALE / DATA E DESCRIZIONE ULTIMA MODIFICA DELLA SCHEDA

Figure 32 Sample File (Robino & Galanrino)



PER REPARTO ELETTRICO

TAPPO 1 (per elttricisti): RASO
TAPPO 2 (per elttricisti): FUNGO SUGHERO
TAPPO 3 (per elttricisti):
TAPPO 4 (per elttricisti):

CAPSULA TRASPARENTE (per elttricisti):
CAPSULA MATERIALE METALLICO (per elttricisti): X
CAPSULA PVC CON DISCO METALLICO (per elttricisti): X
CAPSULA PVC SENZA DISCO METALLICO (per elttricisti):
CAPSULA PVC APERTA IN TESTA (per elttricisti):
CAPSULONE (per elttricisti): X

VERIFICA CAMPIONI (ufficio tecnico) DATA VERIFICA UFF TECNICO: VISTO UFF TECNICO

CLIENTE TSELEPOS MACCHINA: FENIX 2 OTTICO COMMESSA: 07147

RAGGRUPPAMENTO ATTREZZATURE

RIFERIMENTO BOTTIGLIE		RIFERIMENTO CAPSULE	
1 - 5 - 9		2 - 1 - 4	
2 - 12 - 13 - 14		3	
3		5 - 6 - 7 - 8	
4		9	
6			
7 - 8 - 10 - 11			

TOT ATTREZZATURE BOTTIGLIE: 6 ATZ COMPLETE
TOT ATTREZZATURE CAPSULE: 4

NOTE UFFICIO TECNICO ALLEGATO NOTE UFFICIO TECNICO:

26/02/2026: PREVEDERE N 1 ATZ SUPPLEMENTARE CAPS IN PIU' RISPETTO AL CARTELLINO. MANCANO ABBI
PER BOTT. 4 - 9 - 11.

NOTE REPARTO MONTAGGIO: ALLEGATO NOTE REPARTO MONTAGGIO:

PRELIEVO CAMPIONI BOTTIGLIE: DATA:
PRELIEVO CAMPIONI CAPSULE: DATA:
PRELIEVO CAMPIONI GABBIETTE DATA :

ALLEGATO 1 PER FOTO BOTTIGLIE:
ALLEGATO 2 PER FOTO BOTTIGLIE:
ALLEGATO 3 PER FOTO BOTTIGLIE:
ALLEGATO 4 PER FOTO BOTTIGLIE:

At this stage, the sales manager communicates sample availability via e-mail, so that Mechanical Technical Office/Sample Room can practically take charge of them. Then, this last functional unit activates a procedure to verify them, which consists in a technical analysis, aimed at establishing their compatibility with the machinery. To sum up, the final goal is that of verifying order feasibility, so that this one can officially be validated at the end of this macro-phase.

To deal with this step at best, a priority in the analysis is assigned to the ongoing orders, with a target in the verification time of 7-8 working days. This process is handled by manual measurements, whose relative results and potential criticalities are reported in the already mentioned file dedicated to sample analysis, which is updated both on *MS Access* and by paper version *(Robino & Galandrino S.p.A, 2025).* Occasionally, if necessary, this can be integrated by some *MS Word* and/or *MS Excel* files, for instance: the one generated in case of abundant sample number or the one containing the prefilled sample list, provided by the customer.

In the following, the summary of the most important checks to be performed during this process step, which are basically the same that have already been mentioned in paragraph 3.2.2, when describing the feasibility study phase (*Robino & Galandrino S.p.A, 2025)*:

- Bottle dimensional check (diameter and shape determination);
- Bottle colour analysis to verify cap presence;
- Bottle and capsule/wire-hood matching verification (based on the information reported in the *Cartellino* and in the *Sample File*, sent by Commercial Office, where pairings are included);
- Capsule centring analysis;
- Concerning capsuling, in case of doubt, possible physical tests in Testing Room;
- Machinery specification analysis, particularly considering those characteristics that influence change parts the most, such as speed, head types and bottle paths.

Upon completion of all these analyses, the arisen specifications can be verified to assess whether they are compatible with everything that had been included by sales managers in the *Cartellino*. This means that it is then possible to compare the information in the *Cartellino* with the elements that are really needed, in such a way to verify and confirm the number and type of change parts for any considered format, including all supplementary groups. These ones are plastic change parts for bottles, bells and bottleneck caps, that will be introduced successively, as an integration to the machine, while it will already be being processed *(Robino & Galandrino S.p.A, 2025)*.

Whenever some discrepancies between analysed elements and foreseen ones were detected, these would be pointed out, together with all test results. They would be noted by technicians in the *Sample File*, whereas the sales manager would be entitled to communicate them to the customer *(Robino & Galandrino S.p.A, 2025)*. Moreover, during this phase, it is important to try minimizing change part number and type, which is also one of the aims in the offer phase. Indeed, if it were actually and practically possible to employ the same change part for different formats, setup times – and downtimes, consequently - could be reduced, as well as costs.

3.3.3 ORDER VALIDATION – TECHNICAL ANALYSES

In order to detailly analyse this order validation procedure, it is necessary to describe the distinguishing aspects of the key steps which make it up, that need to be implemented for any order.

Bottle dimensional control and verification: this is a generic test, to be performed for any machine type, consisting in bottle manual measurements, that are aimed at verifying order feasibility, in terms of dimensions and shapes. Specifically, it is needed to measure any single bottle format by a vernier calliper, keeping track of: maximum diameter in case of cylindrical bottles, both maximum diameters detected on major and minor ones in case of conical bottles, longest side in case of squared bottles and shape denomination in case of special bottles. In performing these measurements, it is necessary to consider some limits, which are specifically shown in Table 1: the allowed shape, the minimum and maximum diameter ranges, according to which machines can work, and bottle height, that needs to be analysed to verify its stability in the field of the agreed change part. Concerning this aspect, a distinction based on the product type (still or sparkling wine) is needed; indeed, in case of sparkling wine, technicians need to include the cap in measuring bottle height. Moreover, it is important to state which cap type is employed on any single format (satin, screw, mushroom, "T"). Results are reported not only in the *Sample File*, but also on bottles themselves, which are numbered too. Upon them, it will finally be possible to determine the type and amount of necessary change parts, specifying which bottle number is paired with each of them *(Robino & Galandrino S.p.A, 2025).*

Table 1 General limits (Robino & Galandrino S.p.A, 2025).

Parameter	**Value**
Bottle workable diameter	**55 – 120 mm**
Bottle workable height	**Max 360 mm**
Admitted shape	cylindrical, conical, squared (max side), special (to be evaluated)

Wire-hooder control: specific for this type of machines, this test analyses caps, wire-hoods, bottle shape and height and the necessity to install any special parts or groups, which had not been specified in the order. Upon completion of all these tests, total type and number of required change parts can be reported in the *Sample File (Robino & Galandrino S.p.A, 2025)*.

Capsuling machine control: specific for this kind of machinery, this test is aimed at determining the necessary change parts for capsule and bottle orientation, capsule distribution and capsuling as such, so that to ensure high quality in the finished result. Particularly, this phase focuses on analysing capsules, their compatibility with bottles and with the type of capsuling required in the order, capsuling quality and the necessity to install any special parts or groups, which had not been specified in the order. Moreover, in case of optical capsules, it is needed to analyse the type of embossed spot, so that to verify the compatibility of the included optical sensors with the samples. Once results are obtained, total type and number of necessary change parts is determined and reported in the *Sample File (Robino & Galandrino S.p.A, 2025)*.

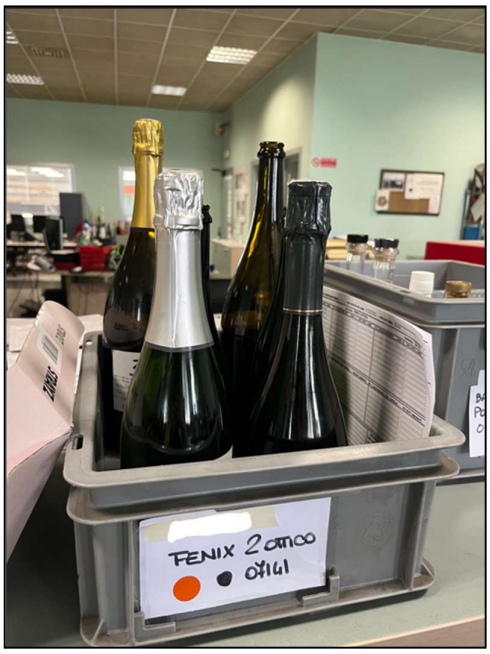
It is important to notice that sample control, which is aimed at verifying order adequacy, turns out to be of particular interest in the case of capsuling, since the number of variables is significantly high and it is of primary importance to identify by time any potential difficulties or impossibilities that may show up throughout the process. Concerning this aspect, it is fundamental to quickly inform

Commercial Office about any changes to be made to the capsules and the consequences that the company would face, in case these modifications were not accepted by the customer.

To guarantee better clarity and exhaustiveness in relation to these first three steps, it is possible to detailly describe the technical procedure the company follows to determine change part number and type. This can be found in the Appendix, in the section specifically dedicated to paragraph 3.3.3.

Stamp application (see Figure 33): application of an orange stamp on the box containing the samples belonging to a given order, in such a way to show that these ones have already been verified; further application of a black stamp, in case of having picked up the necessary capsules/wire-hoods, which are selected in a number of 4/5 for each type, so that it is possible to send them to the Warehouse and finally go on with the production of all necessary change parts in Machining Department *(Robino & Galandrino S.p.A, 2025)*.

Figure 33 Example of a box with already applied stamps (Robino & Galandrino)



Feasibility verification of each format workability and validation of order specifications: technicians compare the specifications reported in the previously mentioned *Cartellino* with what really turns out to be necessary, based on analysis data and results. In this way, it will be possible to verify the feasibility of what had already been agreed upon by sales managers and to officially define order technical configuration. Moreover, change parts and additional groups will be determined, and the *Sample File* will ultimately be revised, updated and sent to the sales managers. In other words, this phase is aimed at the confirmation or modification of previously inserted data, by communicating any specification change requests to Commercial Office, to be negotiated again with the customer. In this case, whenever any information and/or answers from Commercial Office are available, these ones need to be written in the usual *Sample File*, so that Mechanical Technical Office/Sample Room receives its updated version, which shows the acceptance of changes to specifications. At this point, technicians can repeat the analyses depicted in the points above, with the goal of verifying that all order specifications have been clarified and validated. If this did not occur, it would be necessary to continue pointing out any non-conformities and verifying all further technical modifications, by

sending any requests to Commercial Office, in view of "work in progress" *(Robino & Galandrino S.p.A, 2025)*.

At the end of this procedure, once the order will have officially been validated, this will be definitively communicated to Mechanical Technical Office and production units. Particularly, an engineering request will be sent to Mechanical Technical Office to design all necessary components, so that production commitments can be defined and change part construction can then be allowed to go on in Machinery Division. This will be made possible through the assignment of a code to the raw part, which is then committed to production to go on with the undertaken change part manufacturing, that will be customized for each capsule/wire-hood and for each bottle. Moreover, samples, first sent to the Warehouse after having defined production commitments, will be passed on afterwards to Assembly Division for final machine inspection and then again to Mechanical Technical Office to prepare machinery handbooks. In the end, they will be picked up again and stored in the Warehouse for a year, as a reference for any potential fixing, machine changes or post-delivery support, always using the *Sample File*, on *MS Access* and by paper version, as a reference to consult for any specifications about samples *(Robino & Galandrino S.p.A, 2025)*.

To conclude the description of this procedural phase, it is fundamental to specify that sample grouping, aimed at determining which of them are allowed to share the same change part, is primarily defined, at this step, on a visual basis. Its adequacy and practical applicability on the machinery will only be definitively verified during machine production first and final testing then.

The flowchart related to the order validation step is inserted in the Appendix, in the section dedicated to paragraph 3.3, specifically in Figure 53. It was prepared with the same purposes that have already been previously depicted.

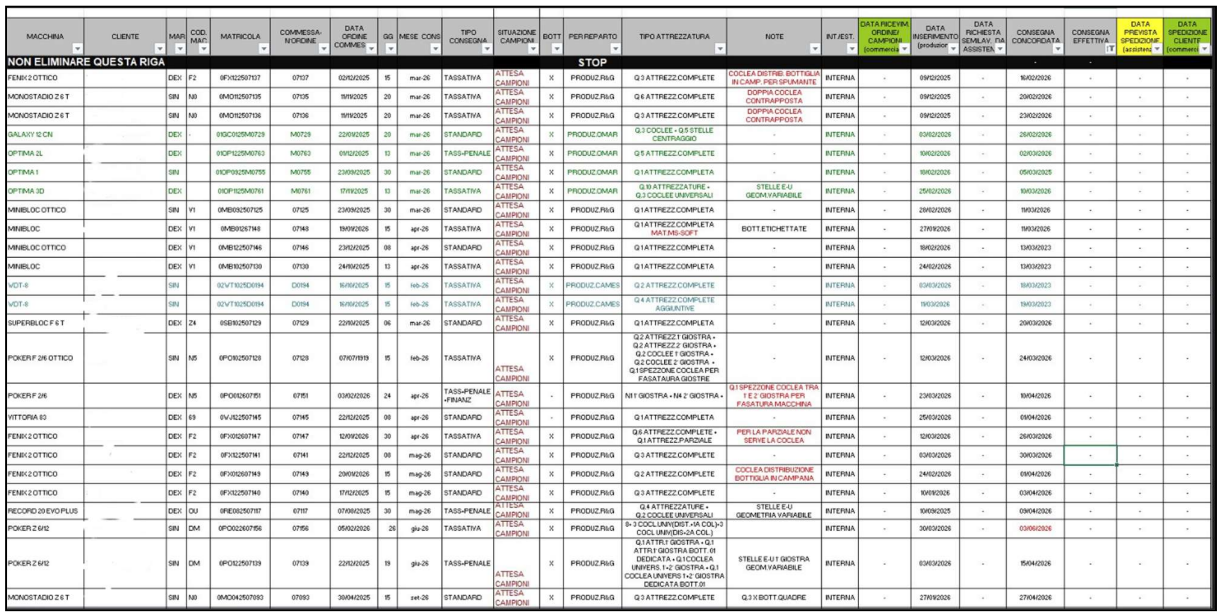
3.4 CHANGE PART ENGINEERING AND PRODUCTION PHASE

3.4.1 CHANGE PART ENGINEERING

Once the order has been validated, the following phase is activated. This one consists in engineering planning and change part design.

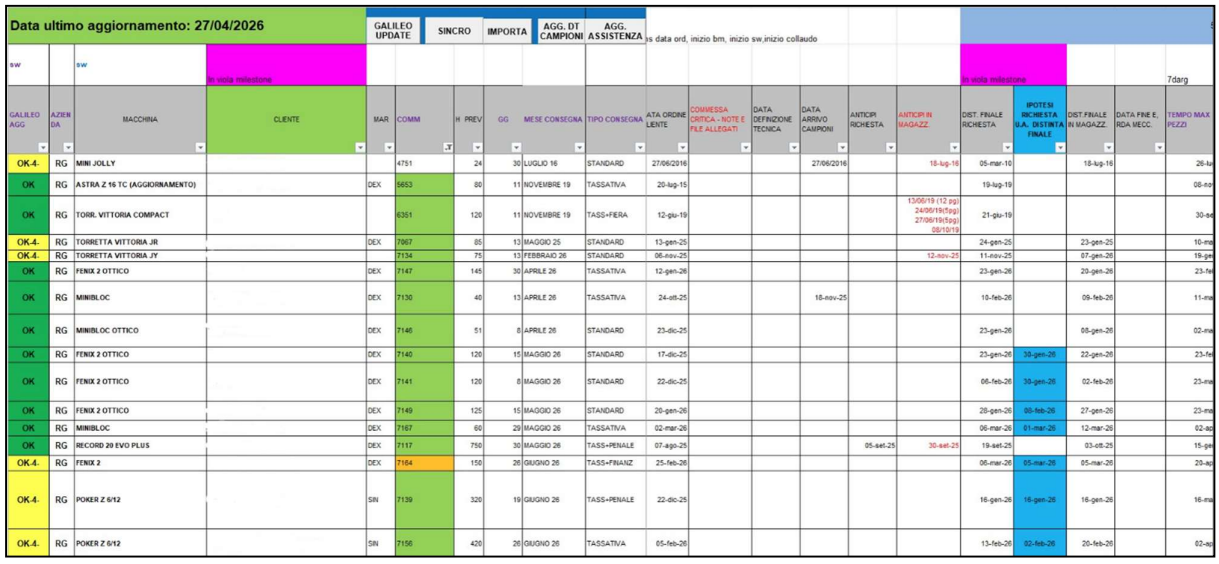
To detailly describe this stage, the first step is performed by Sample Room/Mechanical Technical Office, which must inform production units about all useful details. Specifically, considering the manufacturing needs of all three companies within the group, it fills in a *MS Excel* file (see Figure 34), dedicated to the engineering of bottle change parts only, since these are the only ones to be in principle specifically designed. In this file, technicians specify the orders to be processed; this is usually done monthly, even though it is possible to largely advance some change parts, maybe to accelerate the production of their related machine, in view of some exhibitions, prior to the final delivery to the customer. Moreover, starting from what is stated in the *Cartellino*, employees include a very short summary of the most important additional information, even though this is still incomplete, just to specify some details about the key characteristics of the change parts to be produced. By doing so, some useful clarifications can be provided to Mechanical Technical Office for the engineering phase and, generally, to whoever checks the file for informational purposes. Finally, after having inserted all data related to the necessary change parts, it is needed to define a date for production order emission, with the goal of determining the moment by which these components must be available for production. This date can also be verified on *JGalileo*, the ERP used by the company, and on the *SLP* platform, a specific interface that allows to more quickly check the order advancement status, by providing the same data of the ERP.

Figure 34 Bottle change part File (Robino & Galandrino)



MACCHINA	CLIENTE	MAR.	COD. MACC.	MATRICOLA	COMMESSA-N°ORDINE	DATA ORDINE COMMES.	GG	MESE CONS	TIPO CONSEGNA	SITUAZIONE CAMPIONI	BOTT	PER REPARTO	TIPO ATTREZZATURA	NOTE	INT./EST.	DATA RICEVIM. ORDINE/ CAMPIONI (commerci	DATA INSERIMENTO (produzior	DATA RICHIESTA SEVILAV. ITA ASSISTEN	CONSEGNA CONCORDATA	CONSEGNA EFFETTIVA	DATA PREVISTA SPEDIZIONE (assistenz	DATA SPEDIZIONE CLIENTE (commerc
NON ELIMINARE QUESTA RIGA												STOP										
FENIX 2 OTTICO		DEX	F2	0FX022507137	07137	02/02/2025	15	mar-26	TASSATIVA	ATTESA CAMPIONI	X	PRODUZ.RisG	Q.3 ATTREZZ.COMPLETE	COCLEA DISTRIB. BOTTIGLIA IN CAMP. PER SPUMANTE	INTERNA	-	09/02/2025	-	16/02/2026	-	-	-
MONOSTADIO Z 6 T		SIN	N9	0MO012507135	07135	11/11/2025	20	mar-26	TASSATIVA	ATTESA CAMPIONI	X	PRODUZ.RisG	Q.6 ATTREZZ.COMPLETE	DOPPIA COCLEA CONTRAPPOSTA	INTERNA	-	09/02/2025	-	20/02/2026	-	-	-
MONOSTADIO Z 6 T		SIN	N9	0MO012507136	07136	11/11/2025	20	mar-26	TASSATIVA	ATTESA CAMPIONI	X	PRODUZ.RisG	Q.3 ATTREZZ.COMPLETE	DOPPIA COCLEA CONTRAPPOSTA	INTERNA	-	09/02/2025	-	23/02/2026	-	-	-
GALAXY 12 CN		DEX	-	01GC0125M0729	M0729	22/01/2025	20	mar-26	STANDARD	ATTESA CAMPIONI	X	PRODUZ.OMAR	Q.3 COCLEE - Q.5 STELLE CENTRAGGIO	-	INTERNA	-	03/02/2026	-	26/02/2026	-	-	-
OPTIMA 2L		DEX		01OP1225M0763	M0763	01/12/2025	13	mar-26	TASS-PENALE	ATTESA CAMPIONI	X	PRODUZ.OMAR	Q.5 ATTREZZ.COMPLETE	-	INTERNA	-	10/02/2026	-	02/03/2026	-	-	-
OPTIMA 1		SIN		01OP0925M0755	M0755	23/09/2025	30	mar-26	STANDARD	ATTESA CAMPIONI	X	PRODUZ.OMAR	Q.1 ATTREZZ.COMPLETA	-	INTERNA	-	10/02/2026	-	05/03/2025	-	-	-
OPTIMA 3D		DEX		01OP1025M0761	M0761	17/11/2025	13	mar-26	TASSATIVA	ATTESA CAMPIONI	X	PRODUZ.OMAR	Q.10 ATTREZZATURE - Q.3 COCLEE UNIVERSALI	STELLE E-U GEOM.VARIABILE	INTERNA	-	25/02/2026	-	19/03/2026	-	-	-
MINIBLOC OTTICO		SIN	V1	0MB032507125	07125	23/09/2025	30	mar-26	STANDARD	ATTESA CAMPIONI	X	PRODUZ.RisG	Q.1 ATTREZZ.COMPLETA	-	INTERNA	-	28/02/2026	-	19/03/2026	-	-	-
MINIBLOC		DEX	V1	0MB032507148	07148	19/09/2026	15	apr-26	TASSATIVA	ATTESA CAMPIONI	X	PRODUZ.RisG	Q.1 ATTREZZ.COMPLETA	MATAMI-SOFT BOTT.ETICHETTATE	INTERNA	-	27/09/2026	-	19/03/2026	-	-	-
MINIBLOC OTTICO		DEX	V1	0MB122507146	07146	23/12/2025	08	apr-26	STANDARD	ATTESA CAMPIONI	X	PRODUZ.RisG	Q.1 ATTREZZ.COMPLETA	-	INTERNA	-	19/02/2026	-	13/03/2023	-	-	-
MINIBLOC		DEX	V1	0MB102507139	07139	24/10/2025	13	apr-26	TASSATIVA	ATTESA CAMPIONI	X	PRODUZ.RisG	Q.1 ATTREZZ.COMPLETA	-	INTERNA	-	24/02/2026	-	13/03/2023	-	-	-
VDT-8		SIN		02VT102SD0194	D0194	16/09/2025	15	feb-26	TASSATIVA	ATTESA CAMPIONI	X	PRODUZ.CAMES	Q.2 ATTREZZ.COMPLETE	-	INTERNA	-	03/03/2026	-	19/03/2023	-	-	-
VDT-8		SIN		02VT102SD0194	D0194	16/09/2025	15	feb-26	TASSATIVA	ATTESA CAMPIONI	X	PRODUZ.CAMES	Q.4 ATTREZZ.COMPLETE AGGIUNTIVE	-	INTERNA	-	19/03/2026	-	19/03/2023	-	-	-
SUPERBLOC F 6 T		DEX	Z4	0SB102507129	07129	22/09/2025	06	mar-26	STANDARD	ATTESA CAMPIONI	X	PRODUZ.RisG	Q.1 ATTREZZ.COMPLETA	-	INTERNA	-	12/03/2026	-	26/03/2026	-	-	-
POKER F 2/6 OTTICO		SIN	N5	0PO102507128	07128	07/07/1919	15	feb-26	TASSATIVA	ATTESA CAMPIONI	X	PRODUZ.RisG	Q.2 ATTREZZ.1 GIOSTRA + Q.2 ATTREZZ.2 GIOSTRA + Q.2 COCLEE 1 GIOSTRA + Q.2 COCLEE 2 GIOSTRA + Q.1 SPEZZONE COCLEA PER FASATAURA GIOSTRE	-	INTERNA	-	12/03/2026	-	24/03/2026	-	-	-
POKER F 2/6		DEX	N5	0PO012507151	07151	03/02/2026	24	apr-26	TASS-PENALE +FINANZ	ATTESA CAMPIONI	-	PRODUZ.RisG	N.1 GIOSTRA + N.4 2° GIOSTRA +	Q.1 SPEZZONE COCLEA TRA 1 E 2° GIOSTRA PER FASATURA MACCHINA	INTERNA	-	23/03/2026	-	19/04/2026	-	-	-
VITTORIA 6/3		DEX	63	0VJ122507145	07145	22/12/2025	08	apr-26	STANDARD	ATTESA CAMPIONI	-	PRODUZ.RisG	Q.1 ATTREZZ.COMPLETA	-	INTERNA	-	25/03/2026	-	09/04/2026	-	-	-
FENIX 2 OTTICO		DEX	F2	0FX012507147	07147	12/09/2026	30	apr-26	TASSATIVA	ATTESA CAMPIONI	X	PRODUZ.RisG	Q.6 ATTREZZ.COMPLETE - Q.1 ATTREZZ.PARZIALE	PER LA PARZIALE NON SERVE LA COCLEA	INTERNA	-	12/03/2026	-	26/03/2026	-	-	-
FENIX 2 OTTICO		DEX	F2	0FX022507141	07141	22/12/2025	08	mag-26	STANDARD	ATTESA CAMPIONI	X	PRODUZ.RisG	Q.3 ATTREZZ.COMPLETE	-	INTERNA	-	03/03/2026	-	30/03/2026	-	-	-
FENIX 2 OTTICO		DEX	F2	0FX012507149	07149	29/09/2026	15	mag-26	STANDARD	ATTESA CAMPIONI	X	PRODUZ.RisG	Q.2 ATTREZZ.COMPLETE	COCLEA DISTRIBUZIONE BOTTIGLIA IN CAMPANA	INTERNA	-	24/02/2026	-	09/04/2026	-	-	-
FENIX 2 OTTICO		DEX	F2	0FX122507140	07140	17/12/2025	15	mag-26	STANDARD	ATTESA CAMPIONI	X	PRODUZ.RisG	Q.3 ATTREZZ.COMPLETE	-	INTERNA	-	10/03/2026	-	03/04/2026	-	-	-
RECORD 20 EVO PLUS		DEX	OU	0RE002507137	07137	07/09/2025	30	mag-26	TASS-PENALE	ATTESA CAMPIONI	X	PRODUZ.RisG	Q.4 ATTREZZATURE - Q.2 COCLEE UNIVERSALI	STELLE E-U GEOMETRIA VARIABILE	INTERNA	-	10/03/2025	-	09/04/2026	-	-	-
POKER Z 6/12		SIN	DM	0PO022507156	07156	05/02/2026	26	giu-26	TASSATIVA	ATTESA CAMPIONI	X	PRODUZ.RisG	8+ 3 COCL.UNIV(DIST.=IA COL)+3 COCL.UNIV(DIS=2A COL.)	-	INTERNA	-	30/03/2026	-	03/06/2026	-	-	-
POKER Z 6/12		SIN	DM	0PO122507139	07139	22/12/2025	19	giu-26	TASS-PENALE	ATTESA CAMPIONI	X	PRODUZ.RisG	Q.1 ATTR.1 GIOSTRA + Q.1 ATTR.1 GIOSTRA BOTT. 0t DEDICATA + Q.1 COCLEA UNIVERS. 1+2 GIOSTRA + Q.1 COCLEA UNIVERS 1+2 GIOSTRA DEDICATA BOTT.0t	STELLE E-U 1 GIOSTRA GEOM.VARIABILE	INTERNA	-	03/03/2026	-	15/04/2026	-	-	-
MONOSTADIO Z 6 T		SIN	N9	0MO042507093	07093	30/04/2025	15	set-26	STANDARD	ATTESA CAMPIONI	X	PRODUZ.RisG	Q.3 ATTREZZ.COMPLETE	Q.3 X BOTT QUADRE	INTERNA	-	27/09/2026	-	27/04/2026	-	-	-

Simultaneously, Sample Room/Mechanical Technical Office also goes on filling another more general *MS Excel* file (see Figure 35), concerning overall orders, where the same information about change parts is reported in a shrinker way, also specifying their delivery, as well as sample arrival and verification dates. Particularly, the first one, which had already been initially inserted in red colour by production units, is compared with the last one; if this comparison succeeds, the colour is changed into a green one, and the validated date is reported in the file specifically concerning change parts.



Data ultimo aggiornamento: 27/04/2026 — GALILEO UPDATE | SINCRO | IMPORTA | AGG. DT CAMPIONI | AGG. ASSISTENZA

GALILEO AGG	AZIENDA	MACCHINA	CLIENTE	MAR	COMM	H PREV	GG	MESE CONSEGNA	TIPO CONSEGNA	ATA ORDINE LIENTE	COMMESSA CRITICA - NOTE E FILE ALLEGATI	DATA DEFINIZIONE TECNICA	DATA ARRIVO CAMPIONI	ANTICIPI RICHIESTA	ANTICIPI IN MAGAZZ.	DIST. FINALE RICHIESTA	IPOTESI RICHIESTA U.A. DISTINTA FINALE	DIST.FINALE IN MAGAZZ.	DATA FINE E. RDA VECC.	TEMPO MAX PEZZI
OK-4-	RG	MINI JOLLY			4751	24	30	LUGLIO 16	STANDARD	27/06/2016			27/06/2016		18-lug-16	05-mar-16		18-lug-16		26-lu
OK	RG	ASTRA Z 16 TC (AGGIORNAMENTO)		DEX	5653	80	11	NOVEMBRE 19	TASSATIVA	20-lug-15						19-lug-19				08-no
OK	RG	TORR. VITTORIA COMPACT			6351	120	11	NOVEMBRE 19	TASS+FERA	12-giu-19					13/06/19 (12 pg) 24/09/19(5pg) 27/09/19(5pg) 08/10/19	21-giu-19				30-se
OK-4-	RG	TORRETTA VITTORIA JR		DEX	7067	85	13	MAGGIO 25	STANDARD	13-gen-25						24-gen-25		23-gen-25		10-ma
OK-4-	RG	TORRETTA VITTORIA JY			7134	75	13	FEBBRAIO 26	STANDARD	06-nov-25					12-nov-25	11-nov-25		07-gen-26		19-ge
OK	RG	FENIX 2 OTTICO		DEX	7147	145	30	APRILE 26	TASSATIVA	12-gen-26						23-gen-26		20-gen-26		23-fe
OK	RG	MINIBLOC		DEX	7130	40	13	APRILE 26	TASSATIVA	24-ott-25			18-nov-25			18-feb-26		09-feb-26		11-ma
OK	RG	MINIBLOC OTTICO		DEX	7146	51	8	APRILE 26	STANDARD	23-dic-25						23-gen-26		05-gen-26		02-ma
OK	RG	FENIX 2 OTTICO		DEX	7140	120	15	MAGGIO 26	STANDARD	17-dic-25						23-gen-26	30-gen-26	22-gen-26		23-fe
OK	RG	FENIX 2 OTTICO		DEX	7141	120	8	MAGGIO 26	STANDARD	22-dic-25						06-feb-26	30-gen-26	02-feb-26		23-ma
OK	RG	FENIX 2 OTTICO		DEX	7149	125	15	MAGGIO 26	STANDARD	26-gen-26						26-gen-26	06-feb-26	27-gen-26		23-ma
OK	RG	MINIBLOC		DEX	7167	60	29	MAGGIO 26	TASSATIVA	02-mar-26						06-mar-26	01-mar-26	12-mar-26		02-ap
OK	RG	RECORD 20 EVO PLUS		DEX	7117	750	30	MAGGIO 26	TASS+PENALE	07-ago-25				05-set-25	30-set-25	19-set-25		03-ott-25		15-ge
OK-4-	RG	FENIX 2		DEX	7164	150	26	GIUGNO 26	TASS+FINANZ	25-feb-26						06-mar-26	05-mar-26	05-mar-26		20-ap
OK-4-	RG	POKER Z 6/12		SIN	7139	320	19	GIUGNO 26	TASS+PENALE	22-dic-25						16-gen-26	16-gen-26	16-gen-26		16-ma
OK-4-	RG	POKER Z 6/12		SIN	7156	420	26	GIUGNO 26	TASSATIVA	05-feb-26						13-feb-26	02-feb-26	20-feb-26		02-ap

Figure 35 Order File (Robino & Galandrino)

Data ultimo aggiornamento: 27/04/2026				GALILEO UPDATE	SINCRO	IMPORTA	AGG. DT CAMPIONI	AGG. ASSISTENZA	ut						ut
sw		sw	in viola milestone												
GALILEO AGG	AZIENDA	MACCHINA	CLIENTE	MAR	COMM	H PREV	GG	MESE CONSEGNA	TIPO CONSEGNA	ATTREZZ. DATA ARRIVO CAMPIONI	ATTREZZ. DATA VERIFICA CAMPIONI	ATTREZZ. DATA DISTINTA IN MAGAZZINO	ATTREZZATURE QUANTITA' E TIPO	ATTREZZATURE NOTE PER LA COSTRUZIONE	ATTREZZ. CONSEGNA RICHIESTA	ATTREZZ. CONSEGNA EFFETTIVA
OK.4.	RG	MINI JOLLY			4751	24	30	LUGLIO 16	STANDARD	S	S	S	S	S	S	S
OK	RG	ASTRA Z 16 TC (AGGIORNAMENTO)		DEX	6653	80	11	NOVEMBRE 19	TASSATIVA							
OK	RG	TORR. VITTORIA COMPACT			6351	120	11	NOVEMBRE 19	TASS+FIERA							
OK.4.	RG	TORRETTA VITTORIA JR		DEX	7067	85	13	MAGGIO 25	STANDARD							
OK.4.	RG	TORRETTA VITTORIA JY			7134	75	13	FEBBRAIO 26	STANDARD							
OK	RG	FENIX 2 OTTICO		DEX	7147	145	30	APRILE 26	TASSATIVA	23/02/2026	12/03/2026	01/04/2026	Q.6 ATTREZZ COMPLETE + Q.1 ATTREZZ PARZIALE	PER LA PARZIALE NON SERVE LA COCLEA	26/03/2026	
OK	RG	MINIBLOC		DEX	7130	40	13	APRILE 26	TASSATIVA	18/11/2026	24/02/2026	23/03/2026	Q.1 ATTREZZ COMPLETA		13/03/2026	
OK	RG	MINIBLOC OTTICO		DEX	7146	51	8	APRILE 26	STANDARD	16/02/2026	16/02/2026	26/03/2026	Q.1 ATTREZZ COMPLETA		13/03/2026	
OK	RG	FENIX 2 OTTICO		DEX	7140	120	15	MAGGIO 26	STANDARD	19/02/2026	06/03/2026		Q.3 ATTREZZ COMPLETE		03/04/2026	
OK	RG	FENIX 2 OTTICO		DEX	7141	120	8	MAGGIO 26	STANDARD	13/02/2026	25/02/2026		Q.3 ATTREZZ COMPLETE 29/04/2026 AGGIUNTE 6 BOTTIGLIE + 3 CAPS SOLO DA DISTRIBUIRE		30/03/2026	
OK	RG	FENIX 2 OTTICO		DEX	7149	125	15	MAGGIO 26	STANDARD	16/02/2026	20/02/2026		Q.2 ATTREZZ COMPLETE	COCLEA DISTRIBUZIONE BOTTIGLIA IN CAMPANA	01/04/2026	
OK	RG	MINIBLOC		DEX	7167	60	29	MAGGIO 26	TASSATIVA	31/03/2026	07/04/2026		8 ATZ COMPLETE		08/05/2026	
OK	RG	RECORD 20 EVO PLUS		DEX	7117	750	30	MAGGIO 26	TASS+PENALE	28/08/2025	09/09/2025		Q.4 ATTREZZATURE + Q.2 COCLEE UNIVERSALI	STELLE E-U GEOMETRIA VARIABILE	20/04/2026	
OK.4.	RG	FENIX 2		DEX	7164	150	26	GIUGNO 26	TASS+FINANZ	17/03/2026	18/03/2026		3 ATZ COMPLETE		05/06/2026	
OK.4.	RG	POKER Z 6/12		SIN	7139	320	19	GIUGNO 26	TASS+PENALE	13/02/2026	24/02/2026		Q.1 ATTR.1° GIOSTRA + Q.1 ATTR.1° GIOSTRA BOTT. 01 DEDICATA + Q.1 COCLEA UNIVERS. 1°+2° GIOSTRA + Q.1 COCLEA UNIVERS 1°+2° GIOSTRA DEDICATA BOTT 01	STELLE E-U 1° GIOSTRA GEOM.VARIABILE	04/05/2026	
OK.4.	RG	POKER Z 6/12		SIN	7156	420	26	GIUGNO 26	TASSATIVA	10/03/2026	16/03/2026 NO ABBINAM.		8+ 3 COCL.UNIV(DIST.+1A COL)+3 COCL UNIV(DIS+2A COL)		03/06/2026	

At this point, the orders to be processed are also added to the workplan internal to Mechanical Technical Office, specifying engineering and nesting dates for the commissioned change parts. This is done considering that technicians are entitled to the engineering of the components to be installed on the machines produced by all three companies within the group, satisfying both the requests of new productions and those being managed for after sales purposes. The parts to be engineered and designed, being classified as bottle change parts, are specifically grouped into two families: bottle conveyor and in-phase bottle translation, namely, respectively, the so-called plane plastics, processed by the pantograph, and the infeed screws, subject to milling and turning operations.

Then, the employees entitled to change part engineering take the related samples and measure bottle formats; this is done both manually and through some dedicated 3D scanners, which are compatible with complex shapes. Differently with respect to what happens during feasibility verification and order validation phases, in this case bottles are not measured in absolute terms, rather in relation to their specific positions on the machinery. The obtained measurements are reported on paper drawings, which are also virtually saved on PDM. Then, these customized components are engineered and made available, correlated of their master data and documents (3D and 2D drawings, PDF, etc…).

Once the necessary components for machine construction are progressively engineered, according to the described methodology, the complete Bill of Materials can be gradually defined and organized into assemblies, groups, sub-groups, father-son relationships among the parts. Furthermore, it is the designer himself who commits these codes, by generating the related production commitments, which are then sent to Purchasing Department, so that production orders can be completed and distinguished, depending on whether manufacturing is carried out in-house or not.

These production commitments, being precisely linked to each considered component, are generated on *JGalileo*, even though they can be more easily accessed on the already mentioned *SLP* platform. Moreover, considering plane plastics and infeed screws, once each one has been engineered, it is filed in a dedicated folder entitled to Machining Department; specifically, in the case of plane plastics, the designer inserts the engineered ones in the folder dedicated to nesting operations. On the contrary, INOX parts are outsourced to external suppliers.

Focusing on capsule/wire-hood change parts, it has already been pointed out that they are kept into proper account, together with bottle ones, in the initial feasibility study and order validation phases. Therefore, these two component families are handled together during these two preliminary stages related to order evaluation, but, if the engineering and production process is concerned, they follow two different and separated routes. Indeed, as previously mentioned, bottle change parts are subject to an engineering-to-order logic, whereas capsule/wire-hood ones follow a sample-based production flow. Consequently, the first are always designed from scratch, whereas the second are not subject to this engineering phase. Simply, during the order validation stage, the pre-worked part that seems to better fit each capsule/wire-hood format is selected and paired with it, based on the available drawings and primarily making a visual consideration. Then, the generic code of the pre-worked part associated with each of them is engaged, so that their related production order can be issued. Concerning the code, this one can be referred to the drawing of a specifically considered change part type or to a generic file, that embodies several drawings related to different formats of the given change part.

3.4.2 CHANGE PART PRODUCTION

Once the engineering phase is concluded, it is the time of Purchasing Department, which plays a crucial role when it is necessary to buy the components and the materials required for in-house production and to choose the most appropriate suppliers and accurately manage the relationships with them, in case of externalised processing. Concerning this aspect, purchasing managers issue the production orders related to the components specifically required by each machine, keeping track of them through the ERP *JGalileo.* Specifically, two types of production orders are generated: the one linked to the machine and the one concerning each single part. The first one shows three dates, respectively: the one by which components – already processed by external suppliers or ready to be internally machined - need to be received, the one concerning material transfer in the assembly area and the one linked to machine final delivery to the customer. The second document contains other three dates, which are different from the ones that have just been listed and which concern: specific part commitment, part processing start and part final receipt in the assembly area.

At this point, once necessary change part drawings are received and the requested material is delivered, workers in Machining Department start writing the specific machining program, needed to process the parts and finally produce the specified components. Detailly, infeed screws are produced at company's main site, whereas plane plastics are sent to an external site, which belongs to Machining Department but is located in a different building, where they are produced by a pantograph. Concerning capsule/wire-hood change parts, when it comes to their production, Machining Department processes their related pre-worked components, by specifically adapting them to sample characteristics and dimensions.

Once all these components have been worked and turn out to be physically available, they are deposited in the WIP Warehouse, ready to be transferred to the following productive steps. Of course, when dealing with plane plastics, which are processed in the external site, a further logistic step is required to transfer produced workpieces coming out of the secondary production site to the headquarter, so that to finally deposit them in the Warehouse. Concerning this point, when the pallet containing all processed plastics is delivered, it is the pallet itself which is unloaded and deposited in the WIP Warehouse.

When it is required, the necessary change parts are taken from the Warehouse and assigned to the assembly areas to finally commit them to the last testing step. The tester receives the samples, including the ones delivered in the second sampling step, installs the change parts required by each format and finally verifies, for each of them, both mechanical interfaces first and change part

adequacy then. If some anomalies are detected, the problematic components need to be engineered and/or produced again. On the contrary, if everything is good, the last step is about filling in the so-called *Cover*, namely a file, to be integrated in the Handbook for machine usage and maintenance, that will be used as a support to help the customer dealing with format changes. Final documents and samples are then sent to Mechanical Technical Office, so that to use the second ones to perform all necessary measurements, insert the first ones in the Handbook and finalize its ultimate draft. The whole process finishes with the FAT, a verification test, during which all formats are processed on the machinery in front of the customer, so that he can formally and officially accept machine delivery.

The flowchart related to change part engineering and production step is inserted in the Appendix, in the section dedicated to paragraph 3.4, specifically in Figure 55.

3.5 AFTER SALES ASSISTANCE PHASE

The last process phase, which needs to be depicted to complete changeover process overall view, is carried out by the After Sales Department. Considering this, it is fundamental to first introduce this functional unit, so that to familiarize with it and immediately clarify its primary relevance, from both an economic and productive point of view. Indeed, a considerable percentage of company's total sales and profits is due to spare parts and format changes. Concerning this aspect, it is interesting to notice that, if compared to the orders related to a new machine, the ones entitled to the After Sales register much higher profit margins, thanks to a significantly more favourable ratio between revenues and costs. Particularly, still assuming the high profitability of this whole functional department, it needs to be specified that, within it, it is bottle change parts, in particular, that represent the greatest revenue source.

To get into it, this company's unit is specifically entitled to any kind of support and assistance that the customer needs, from the moment the finished machine leaves production site up to its final disposal. To make some examples, the After Sales Department deals with on-site machine installation, by integrating it within client's overall bottling line, as well as with defective part replacement or subsequent machine maintenance, which requires three annual audits. Concerning change parts, among the supporting tools provided to the customer, there is a dedicated section of the Handbook for machine usage and maintenance. This one is the already mentioned *Cover,* which helps him dealing with format changes, by specifying a list of the necessary ones, in relation to the considered order. All relevant details concerning the information introduced in the *Cover* are reported in the Appendix, in the section dedicated to paragraph 3.5.

Moreover, it has been noticed that this unit also has its own contractual and commercial autonomy, with customers directly contacting it, not only when they need to process a new format on a machine that they have already bought, but also when they want to buy a new one. This aspect provides this office with a key strategic role, when it comes to managing commercial dealings and continuous relationships with clients, who place their faith in this department. Because of this consideration, the topic will be largely and specifically analysed in chapter 6.

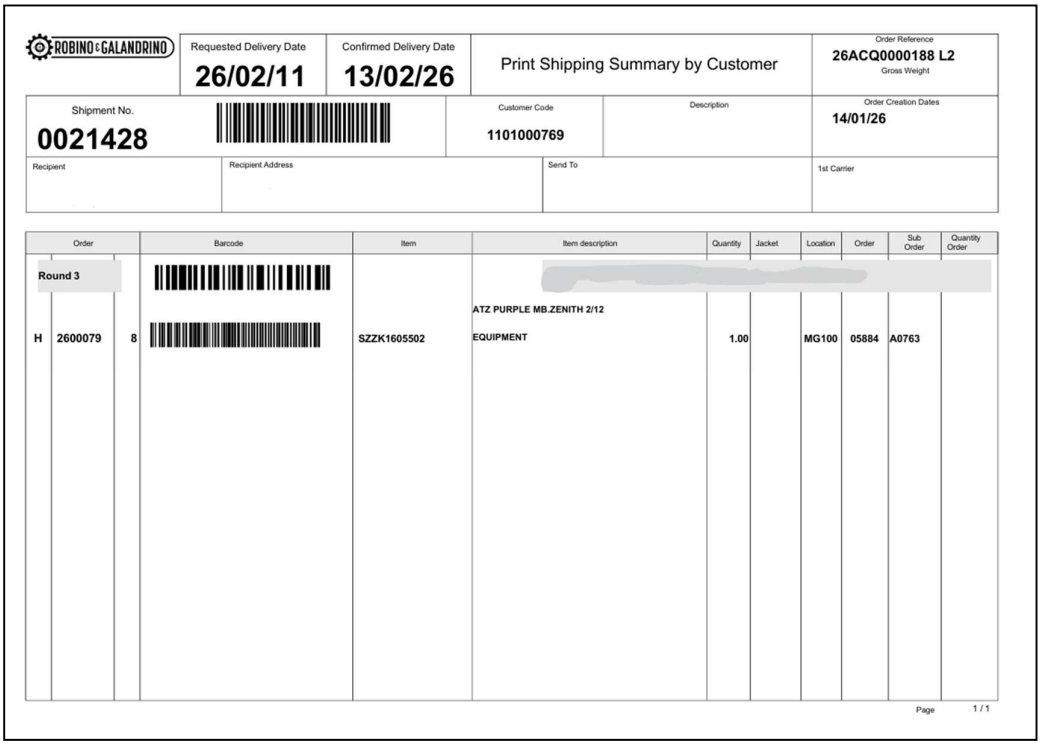
To detailly describe how this functional unit intervenes in the changeover process, specifically coping with its final step, it needs to be explained that its intervention occurs when the customer sends an assistance request, asking to evaluate the possibility of processing a new bottle/capsule/wire-hood format on a previously bought machine. This is always allowed, since the company has decided not to specify any obsolescence date. This means that any new format can always be adapted to an already existing machinery, of course if complying with some specific feasibility limits, but independently of its purchasing year.

In this case, the process starts by asking the customer to send bottle technical drawing, so that to first consider its height. Concerning this aspect, it is necessary to make a distinction based on product type (Spumante/sparkling wine or still wine/oil/etc…), since this one affects the measurement itself, as it has already been explained in paragraph 3.3.3. Moreover, in the first case, beyond bottle technical drawing, it is also necessary to ask for those ones depicting the wire-hood and the capsule paired with it. On the contrary, if the second product type is concerned, only capsule technical drawing is additionally required, since the wire-hood is not used on this other product kind.

Based on the available data, the already installed machines in customer's line are analysed. Detailly, considering their related *Cartellino*, all currently inserted change parts are inspected to evaluate their compatibility with the new format, which is about to be introduced. If this test has a positive outcome, the customer will be simply informed, specifying which are the kinds of change parts to be used to process this new format, among the different ones that he already owns. On the contrary, if this analysis ends with a negative result, it will be necessary to engineer and produce some new change parts.

In relation to this second scenario, the After Sales Department creates a new offer and, if detecting any dimensions (diameter and/or height) or shapes, which reveal to be out of the standard range, it sends a request for a technical, economic and/or timing feasibility study. In the best-case scenario, this one is optimally requested through a ticket; otherwise, an e-mail is sent or an informal oral communication is made. Then, a process flow is implemented, which is the same of the one that has already been described for commercial offers related to new machines, in paragraph 3.2.2. If the offer is accepted, the After Sales will receive a final order from the customer, according to which a production commitment will be generated, through the ERP *JGalileo*. Two dates are then established: the first one concerns the moment by which all necessary material needs to be available in the Assistance Department, whereas the second one shows the moment by which this one must be sent to the customer, considering, in the middle, a useful time for change part production.

Specifically considering change part production process, the first step concerns the request, made by the Assistance Department, of sending bottle and related capsule/wire-hood physical samples. Upon their receipt, they are verified, so that Mechanical Technical Office can then commit itself to the engineering of the dedicated bottle change parts and to the sample-based evaluation of the capsule/wire-hood ones. Once this step is completed, Mechanical Technical Office fills in the related production commitment, which had previously been created by the After Sales, engaging the specific codes of the groups to be produced. At this point, Purchasing Department generates the production orders themselves, in relation to each single part to be processed (see Figure 36). After that, the necessary components are produced. Detailly, as already stated in paragraph 3.4.2, capsule and wire-hood change parts are specifically adapted to sample measures; concerning bottle change parts: INOX components are outsourced to external suppliers, infeed screws are machined in inside Machining Department and plane plastics are inserted into the file dedicated to nesting operations and then sent for cutting to the in-house but outside Machining Division. Once production is concluded, finished parts are received by the After Sales and then delivered to the customer, who will finally install them on his own machine.



ROBINO & GALANDRINO

Requested Delivery Date	Confirmed Delivery Date	Print Shipping Summary by Customer	Order Reference
26/02/11	13/02/26		26ACQ0000188 L2 Gross Weight

Shipment No.	Customer Code	Description	Order Creation Dates
0021428	1101000769		14/01/26

Recipient	Recipient Address	Send To	1st Carrier

Order	Barcode	Item	Item description	Quantity	Jacket	Location	Order	Sub Order	Quantity Order
Round 3									
			ATZ PURPLE MB.ZENITH 2/12						
H 2600079 8		SZZK1605502	EQUIPMENT	1.00		MG100	05884	A0763	

Page 1 / 1

Figure 36 Example of a change part production order for a format change (Robino & Galandrino)



ROBINO & GALANDRINO

Requested Delivery Date	Confirmed Delivery Date	Print Shipping Summary by Customer	Order Reference
26/02/11	13/02/26		26ACQ0000188 L2 Gross Weight

Shipment No.	Customer Code	Description	Order Creation Dates
0021428	1101000769		14/01/26

Recipient	Recipient Address	Send To	1st Carrier

Order	Barcode	Item	Item description	Quantity	Jacket	Location	Order	Sub Order	Quantity Order
Round 3									
			ATZ PURPLE MB.ZENITH 2/12						
H 2600079 8		SZZK1605502	EQUIPMENT	1.00		MG100	05884	A0763	

Page 1 / 1

The flowchart related to the physical flow connected to the After Sales Assistance phase is reported in the Appendix, in the section dedicated to paragraph 3.5, specifically in Figure 56.

3.6 OVERALL PROCESS VIEW

With the aim of visualizing the whole considered process, in its entirety and comprehensiveness, two additional flowcharts were prepared. The first one shows an overall view of sample and related change part physical management process. It was included to represent the sequence of actions and decisions, to be implemented in this context, at a broader and more synthetic detail level, also specifying which functional units are involved in each step management. It can be found in the Appendix, in the section dedicated to paragraph 3.6, specifically in Figure 60.

The second diagram, which can also be found in the Appendix, in the same section dedicated to paragraph 3.6, specifically in Figure 61, represents the documental flow related to this process, in such a way to highlight how the company keeps track of the information linked to the different procedural phases and how this one is actually stored and maintained over time, with the aim of enabling and facilitating its subsequent traceability.

3.7 IDEF0 DIAGRAMS

After having detailly defined the phases that constitute sample and related change part management process, by qualitatively describing their key peculiarities and by constructing their related flowcharts, the following step consisted in the definition of the IDEF0 diagrams. These ones were introduced to better and simultaneously visualize, at the input and output levels, both the physical and documental flows, specific for each procedural step. Indeed, the kind of graphical representation they are based upon allows to hierarchically decompose a production system, starting from a general view and then moving forward towards increasingly specific detail levels, in such a way to describe how resource and information flows interact. Basically, the IDEF0 diagrams integrate the flowcharts, completing process overall view and finalizing its ultimate and general structural hierarchy. In fact, they define the structural bone of the procedure, by drawing up a system's global map, characterized by activities, resources and constraints. On this basis, the flowcharts specifically describe the detailed decision-making process implementation, by showing the timing sequence, the decisional crossroads and the loops (*Curry G.L. & Feldman R.M., 2011)*.

Particularly, IDEF0 diagrams need to be interpreted as such (*Curry G.L. & Feldman R.M., 2011)*:

- Arrows entering from the left side: they represent the inputs, namely what is processed during the activity;
- Arrows coming out of the right side: they represent the outputs produced, namely the results of the activity;
- Arrows entering from the top: they represent the constraints (controls) that regulate or affect the execution of the activity;
- Arrows entering from below: they indicate the resources (physical tools and/or people) that make it possible to carry out the activity.

All these IDEF0 charts can be found in the Appendix, in section 3.7, being specifically dedicated to them. Particularly, it was decided to produce two different IDEF0 diagram sets: one specifically related to the structural hierarchy of new machine production process (see Figures 62-68); the other one, on the contrary, depicting the one which considers the requests for new format adaptation to an already installed machine (see Figures 69-73).

4. CRITICALITY ANALYSIS

4.1 KEY CRITICALITIES

The fourth macro-phase of this dissertation is dedicated to a critical analysis of the results obtained from actual process state mapping, so that to highlight its key issues.

Specifically, the approach that was implemented to reach this purpose was that of following again the process flow and qualitatively describing its most relevant problems, for each of the phases that make it up. Therefore, in the following, these key criticalities are depicted and organized, in such a way to obtain a clear structuring of this chapter. Particularly, they are divided and distinguished, depending on the procedural step where they first emerged.

4.1.1 FEASIBILITY STUDY

In relation to the management of a commercial offer's feasibility study phase, a criticality needs to be highlighted, which is connected to the fact that request centralization and saving is often only and experimentally entitled to Mechanical Technical Office. This means that the initial request from Commercial Office/After Sales Department, which should be respectively made by filling in an official *MS Word* document or by formally sending a ticket, is still often only submitted by e-mail or orally made, which is even worse. Thus, until Mechanical Technical Office does not intervene, by creating the offer project on the PDM, this first one is not tracked, centralized and accessible by everyone.

Moreover, the procedure to save all data concerning change parts in the IT system is still undergoing an experimental phase; therefore, the personnel highlighted the lack of a structured and consolidated approach to deal with it. This leads to a key issue: change part feasibility analyses' outcomes are finally registered in the system but, in most cases, all specific and precise measurements made on the samples are not formally and officially maintained. This means that these tests need to be performed again from scratch, during the subsequent phase, dedicated to the analyses aimed at order validation, as well as even in the final process step, concerning handbook drafting.

Synthetically, a missing element characterizes this process phase, namely the absence of an official, structured and centralized procedure to monitor its status. If this were introduced, it would be possible to officially save and maintain data and measurements, so that these ones could be accessed by anyone needing to consult them, and it would also be easy to clearly show the actual state of the procedure specifically concerning them and their connected requests.

Another critical aspect of this preliminary process phase lies in the too superficial definition of the conditions, according to which a technical feasibility analysis is requested. Indeed, while describing this procedure actual state, it emerged that Table 1, introduced in paragraph 3.3.3 with the name of "General Limits", finally turns out to be a too simplistic and even not fully correct basis, upon which to determine whether and when an offer feasibility technical study requires to be performed. Therefore, this aspect management reveals to be too superficial and approximated: it is needed to introduce some more precise and exhaustive conditions, which feasibility requests must be defined upon.

4.1.2 OFFER-ORDER TURNING STEP

It has been noted that the turning phase from offer acceptance to order definition turns out to be just roughly defined and handled, leading to superficial management of the contractual aspect. Differently said, the order confirmation phase is too elusive, since it misses an official commercial offer

validation step, before this one definitively becomes an order. This scenario causes a possible issue, if some aspects of the offer are not analysed and do not emerge in this preliminary definition and validation phase, thus being only disclosed at already mature process stages, when they are not so easily negotiable with the customer anymore. For this reason, their impact can amplify and become of difficult and costly management and resolution.

Feasibility study requests can be considered as a buffer to lessen these problems; indeed, even though an official commercial offer validation stage is missing, if a request is proactively made to straight analyse and evaluate all critical aspects, these ones will be anyway studied and verified by time. Nevertheless, considering the existing criticalities, which currently characterize the field of feasibility study requests, and which have already been exposed in the paragraph above, this alternative solution clearly results not to be always effective; this critical aspect then remains of primary relevance.

This problem was highlighted and confirmed both by technical functions, namely Mechanical Technical Office, and by commercial ones, represented by Commercial Office and After Sales. Indeed, the first one revealed that, in almost half of the cases to be processed, it occurs, during the engineering phase, to detect some discrepancies between what had been established at the sale moment and what really turns out to be feasible for the considered machinery. It was also explained that this could be easily avoided, if an official offer confirmation step were introduced, during which commercial employees could have a meeting with technical experts, so that to disclose by time any discrepancies and non-feasible elements, before definitively generating the order. This point of view was also confirmed by commercial functions, which clearly stated that an official offer confirmation step should be introduced. This one should consist in a meeting with people entitled to engineering, production and installation steps, so that to correct by time any potential mistakes, also acquiring some further competences and awareness to deal with future offers. Particularly, this was noticed and confirmed by the After Sales Unit, since this one, which must organize and supervise produced machine installation, often encounters some major incompatibility issues in relation to this aspect. These could be in principle avoided, by directly meeting the personnel entitled to accomplish this work, because of these people perfectly ex-ante knowing the productive layout, when dealing with already existing customers.

4.1.3 SAMPLE RECEIPT

Concerning this aspect, a key criticality has been highlighted, which is related to potential discrepancies and non-compatibilities between the two groups of samples, the first one for order validation phase and the second one to support final production stage. Due to these substantial differences in the samples delivered in each of the two steps, some sample-machine incompatibility problems of primary relevance may finally arise. Indeed, any machine is engineered starting from the samples delivered for the initial order validation phase; so, if these ones significantly differ from the ones sent for machine final testing, with these last ones not being compatible with the already produced change parts, some major issues will arise in relation to machinery compatibility with the products to be worked on it.

Furthermore, it is fundamental to notice that a significant delay on customer’s side often occurs in delivering all necessary samples. Sometimes, this can be such to cause a condensation of these two sampling phases and, therefore, a delay in assessing sample-machine compatibility and in validating the order. If this delayed analysis were then concluded in a negative result, this scenario may even entail some further critical consequences, particularly if machine production had already got started or if it were already undergoing an advanced process status, which would represent an even worser situation.

In relation to box preparation phase, this procedure is sometimes complicated by the fact that some pallets are loaded in a rough and casual way; this potential lack of attention and care on customer's side of course leads to an increase in the time needed to prepare the boxes with samples therein, also increasing, among all other aspects, the probability that some sample types are not noticed and thus not picked up. This would cause some significant effects, in case some of them required some dedicated change parts, that would not be taken into account, because of these missing items.

4.1.4 ORDER VALIDATION

All technical controls to test the compatibility between the products to be processed and the machine itself, aimed at validating the order, are manually accomplished; therefore, they reveal to be time-consuming. Particularly, considering those tests concerning bottleneck-shape change parts, the matching analysis is simplified, and the criticality of this aspect is partially reduced, by the availability of a table, which lists all most relevant possible combinations between the shells and the bottleneck-shape caps. This one can be considered as an error detection and prevention system, which supports these analyses, by providing a solid basis to consult to speed up these controls and verify their accuracy. However, these scenarios are not fixed and sure; thus, this verification phase specifically risks to considerably prolong, if the number of combinations to test disproportionately increases, before finding the right one. Clearly, the major consequence of the increase in the time needed to manually test samples is the longer time required to officially validate the order, other than the opportunity cost of the time that the operators entitled to this type of controls could have spent in dealing with other more value-added activities.

Moreover, these problems are worsened by the eventuality of incurring into some relevant human mistakes, which show a particularly high probability to occur, because of these controls' nature, which is cumbersome, prolonged and highly sensitive to precise specifications and tolerance ranges, that operators always need to comply with. In other words, since these tests are highly exposed to some potential inaccuracies in performing measurements, an increase in the probability of making some major mistakes occurs, ultimately producing some potential significant incompatibilities between sold change parts and workable formats.

4.1.5 DISCREPANCIES BETWEEN ORDER PAPER-BASED AND DIGITAL DATABASES

Generally, from a commercial point of view, it has been highlighted that an adequate order digital database is missing, meaning that sometimes the *Cartellini* of the orders that have been processed so far cannot be digitally found and accessed. Indeed, for a long period of time, the order database only figured in its paper-based version; this means that, over those years, all key machine specifications were only registered and stored on paper, causing a particularly complex tracking nowadays. Thus, because of this difficulty in finding all relevant information concerning what was offered and configured in the past, when a format change needs to be implemented on a specific machine, employees almost never have the absolute certainty of being able to offer the most compatible solution.

Specifically, capsule/wire-hood change parts can be left out of the analysis, because of them being managed with an assembly-to-order logic, thus being always more difficultly traceable. However, even in the case of bottle change parts, which are subject to an engineering-to-order logic, therefore always associated with a specific and unique code for each order, it needs to be noticed that this is a relatively recent practice; so, if a misalignment occurs between the two database types, their traceability will be highly affected and complicated. Indeed, if an adequate update of order digital version is missing, it will of course be particularly difficult to ex-post track the necessary data, with

the risk of not being able to understand which change part types had been installed on the considered machine. Due to this, instead of analysing what had been offered in the past and considering this aspect as a reference basis, it will be necessary to start again from scratch, with this producing some uncertainties about the compatibility of what is actually being sold, as well as some major impacts, in terms of extra-time and extra-costs, needed to evaluate customer's requirements again.

4.1.6 BOTTLE CHANGE PART ENGINEERING

As previously explained, bottle change parts are always handled with an engineering-to-order approach. Concerning this aspect, from a technical point of view, the company currently maintains a digital database, storing all bottle change parts that have been engineered up to now, in such a way to keep a clear and easily accessible track of their specifications. This allows to get a valuable starting point for any new request, avoiding the need of starting the engineering process again from scratch, in case some clear similarities with past commissioned orders arise. Nevertheless, this is a relatively recent practice, meaning that some of the data is still only stored in a paper-based version or registered with some "strange" names. This of course generates some possible discrepancies and missing elements, often complicating its ex-post tracking and having technicians re-design some change parts that had already been identically engineered in the past. Therefore, it would be necessary to better organize this documentation digital version, by defining the master data in a standardized way and by integrating all missing information, so that bottle change part drawings always figure within the dedicated "Change parts" folder on the PDM, specifically for each order/part number.

4.1.7 PLANE PLASTIC PRODUCTION

As already stated, the production of these bottle change parts is internally entitled to the company but organized and carried out in a secondary site (see Figure 37). This of course constitutes an issue in terms of logistic burdens, because of which some direct transport costs arise, as well as some indirect ones, due to material losses along production line and lead time increase. This occurs because, near the pantograph which produces these components, there are no precise areas specifically related to each order. Therefore, it often happens that parts belonging to different machines are mixed up together, causing a subsequent relevant loss of time in trying to identify and place them again in their initial destination.



Figure 37 Plane plastic production in the external site (Robino & Galandrino)



Moreover, this criticality is worsened by the lack of a professional role, specifically entitled to the organization of this external site's production and logistic flows. Synthetically, direct management and supervision of this manufacturing site by the company to which it formally belongs is currently missing: this is the reason why this productive dislocation reveals to be so critical.

4.1.8 CAPSULE/WIRE-HOOD CHANGE PART PRODUCTION

As already exhaustively exposed in the paragraphs before, this change part type production follows an assembly-to-order logic. Apart from those components that touch the bottle, such as wire-hood clamps, all other ones are not detailly measured with respect to sample dimensional specifications, but they are simply ex-ante produced as generic semi-processed parts and then paired on a primarily visual basis, depending upon capsule/wire-hood features, defined in each order's *Cartellino;* these pre-worked parts are finally adapted to sample specific dimensions only in a later production step in Machining Department. For example, if considering distribution bells, that turn out to be the kind of change parts mainly exposed to this issue, the iter is the following one: bells' external bodies are preliminarily produced as semi-processed parts; then, the pre-worked component that looks to be the most compatible one is selected, committed to production and finally processed to specifically adapt it to the features of the related sample.

This logic causes an important problem: the code assigned to each change part is not the unique one corresponding to the finished component, rather the one related to the semi-finished item, which is common to many different orders. Therefore, it is only part's general drawing that is uploaded and maintained in the database, not the specific one, showing the precise measures upon which the component was finally processed, depending on the machine where it was intended to be installed.

Consequently, since pairings are mainly defined on a visual basis and codes are not univocally assigned to each part, the company is not able to subsequently detailly track the specifications of the previously produced and installed components. Thus, as already occurred, it may happen that operators do not recognize that a specific format is identical to another one that had already been analysed and processed in the past. Because of this, the risk arises that different change part types are

sold to process the same capsule/wire-hood format or, which is even worse, that some of them do not fit the machinery, then damaging finished product quality.

The first aspect turns out to be problematic because, in case of two different orders belonging to the same customer, this last one already owns the necessary change part. So, if the company accidentally offers him to uselessly buy another one, which is perfectly identical to the one he already owns, it will have him pay some avoidable extra-costs, thus ruining the trust he places in the firm and leading to some major consequences and losses from a reputational point of view. The second scenario is clearly even more impacting, since it produces some major consequences, not only from the economic perspective, but also affecting production and operations.

This second failure mode is caused by the fact that the change part to match is chosen on a primarily visual basis and then straight processed in Machining Department, without having it undergo a parametric engineering phase. This means that the possibility occurs that each item is too superficially defined, causing that it does not perfectly comply with the samples to be worked on the machinery, thus leading to some significant qualitative losses on capsuling/wire-hooding result. This aspect might be even worse: if an incompatibility occurs between the capsule/wire-hood to be worked and the semi-processed change part previously paired with it, some key criticalities will arise at an advanced process stage, when it is more difficult and costly to implement any necessary changes. Indeed, not only some re-processing will be necessary, but a renegotiation with the customer will even have to be evaluated, in case the need arises for some additional or significantly different change parts. For example, some particularly long capsules may require a change in their related rotor/distributor. If capsule measures are only analysed at an advanced process stage, closely to their final production, a considerable risk will occur: if sample initial analysis, which is a purely visual one, terminates with it being paired with a rotor that is not able to accommodate the specifically considered capsule type, this will culminate in a significant quality accident. The only way to avoid this scenario, by getting aware of it in a useful time, lies in the experience of who sells/analyses the components, that asks for a feasibility study by time, so that to plan, right from the beginning, the required special change part. This scenario may be even more worrying, if it occurs when dealing with new format adaptation requests to an already existing machine. Indeed, in those cases, it is not possible to finally test all produced change parts, before officially delivering them; thus, because of the limited number of samples sent during the production phase, it may happen that any potential failures do not emerge, thus being detected only by the customer himself, while using these components to process its products.

Moreover, in a meeting with the After Sales Department, it emerged that the production methodology implemented for capsule/wire-hood change parts reveals to be critical, also considering their future management in a life-cycle perspective. Indeed, whenever it is necessary to restore the components installed on a specific machine, without having a specific code univocally assigned to each of them, it is obvious that the whole process will necessarily need to be repeated from scratch. This occurs because it is clearly impossible to automatically offer another change part, which is certainly known to be perfectly identical to the already installed one. Specifically, since the company never keeps track of any capsule/wire-hood specifications, but only of the generic type of the change part sold, it will necessarily need to measure them again, thus having to ask the customer to send some other samples. Since it has already been analysed that sample receipt and verification phases have their own significant criticalities, it is of no doubt that these are added to the ones specifically due to the assembly-to-order production logic, as well as to the increase in time and costs, that the firm necessarily needs to face to repeat the whole production flow from scratch.

Finally, the issues that have just been described are worsened by the database type that the company currently maintains, in relation to the different formats and kinds of capsule/wire-hood change parts. Indeed, not only it lacks the change part version specifically adapted to the precise order this one belongs to, but it may also sometimes show some discrepancies between the digital and paper-based versions. This means that the drawings of some capsule/wire-hood change part types are only stored in the paper database, causing the digital one not to be updated and having the two of them not being perfectly aligned.

To sum up, since capsule/wire-hood change part management does not only suffer from its inherent issues, but also from the ones due to external preceding flows, it can be concluded that this process point turns out to be one of the most critical ones. Moreover, as emerged in the previous lines, this issue impacts change part production both in relation to new machines and to new format adaptation requests. Detailly, this last scenario constitutes the hearth of this criticality, since it reveals to be particularly impactful for continuous relationship management with the customer in the long run. Indeed, this problem emerges whenever he requires the company to adapt a new format to an already installed machine and finds it unprepared in quickly and accurately meeting his production needs. Considering that that the customer is usually impatient to adequately and promptly satisfy his demand, since he would certainly incur into some major production downtimes if this did not occur, it is obvious that if the company cannot appropriately tackle this issue, this will necessarily produce a significant dissatisfaction, which may be decisive in keeping the customer for future orders, losing his trust and loyalty.

4.1.9 QUALITY CONTROLS

Generally, quality controls highlight a significant decrease in product quality, which is to be found both in relation to the parts being internally produced and to the ones entitled to be worked by external suppliers. This is due to the current social and educational context, where the available workforce for the already mentioned processes reveals to be quantitatively limited, other than increasingly less trained and prepared, leading to some highly problematic consequences in terms of product quality. The higher frequency in components needing to be re-worked then strongly affects operations, causing some possible significant delays, which impact production and ultimately delivery, as well as costs.

Moreover, it has emerged that this issue is worsened by the fact that any potential defects and/or missing parts are usually detected at mature process stages, close to the assembly step. Considering quantitative controls, the reason is the following one: expect for mechanical parts, in all other cases, when the pallet is delivered to the Warehouse, this one unloads it as a whole, not individually by each part. Therefore, since the process misses a quantitative control phase for produced items, the company often incurs into some missing parts, which are identified at an advanced process stage, when it is more complex and costly to deal with these criticalities. From a qualitative point of view, a production step and a professional role specifically entitled to quality controls are missing. Indeed, this kind of analysis is only made on a rough visual basis, while processing by production units or once parts are received by the Warehouse, without measures being formally and specifically monitored up to the assembly step. This produces some possible extra-costs and delays, if some major defects occur, mainly if these are detected in relation to some critical components.

4.1.10 AFTER SALES – NEW CHANGE PART OFFER PHASE

While analysing change part process management from After Sales Department's point of view, it emerged that this unit intervenes when an already existing customer needs to adapt some new product

formats to an already bought machinery. Particularly, considering this context, a criticality was found, which concerns the offer phase of these additional change parts generally lasting for too much time.

Indeed, when selling a new machine, commercial employees first need to appeal the customer and persuade him to buy the machinery, and then also require evaluating a more varied and complex set of factors, according to which the final proposal should be defined. For this reason, it is necessary for the commercial offer phase to be longer, also considering the greater cost impact, that the customer must take on to face this kind of purchase. On the contrary, when dealing with "simple" new format adaptation requests, variables to be considered by the After Sales and final change part costs to be paid by the customer are considerably lower, thus theoretically allowing the offer phase to be much quicker.

Particularly, the problem arises in relation to those situations, where the customer does not accept and finalize the offer at the end of the process. Indeed, in case this one prolongs in time, but is then positively concluded, the costs, also in terms of time, will immediately be recovered, thanks to the revenues earned. On the contrary, if this does not occur, no money will be collected to recover the initial costs faced during the offer phase period, thus leading to these ones to be registered as sunk costs, therefore incurring into some financial losses. Considering this aspect, it is obvious that if this phase is quickly carried out, even in case the customer does not finalize the purchasing operation, the losses arising because of this will be negligible. On the other hand, if this step has a considerably longer duration, thus requiring the company to face some higher costs, also the arising losses will clearly be more affecting and significant.

4.1.11 AFTER SALES – CHANGE PART TEST

Whenever the customer asks for some new change parts to be able to work a new format on a machine he already owns, these ones are engineered and produced starting from bottle/capsule/wire-hood samples he sends. A considerable limitation of this phase lies in the fact that, in case of an order which comes out of the need to adapt a new format to an already installed machine, these change parts cannot be tested on the machinery itself. This differs from the case of change parts to be used on a new machine, which always undergo a final testing phase, before being finally delivered to the customer. Therefore, in the first depicted situation, the probability arises of incurring into some major incompatibilities and inadequacies, producing some significant costs to be paid to recover from the arisen issues. Indeed, it is known that the more mature the process stage during which non-conformities are detected, the higher the costs of coping with them. However, this critical aspect is intrinsic to the process, and the current state of art does not allow to place a remedy that is good enough to significantly reduce its impact.

4.1.12 CHANGE PART MANAGEMENT

In relation to this whole company's process, in each phase, a significant confusion emerged, concerning the definition of what constitutes a change part and the way different types need to be distinguished and paired, depending on machine and sample specifications. Therefore, a misalignment occurs among different functional units, because of the lack of an official and properly formalised list of all those dedicated and customized elements, that are specifically arranged to be interchanged, depending on product formats. Indeed, when these ones significantly differ, they require some diverse and dedicated components to be worked at best, that therefore need to be closely evaluated and managed during the process.

This general confusion was also detected at the linguistic level, because of the absence of a standardized, centralized and shared definition of component database. This causes the eventuality

that, when dealing with people with different working and educational backgrounds, each of them uses some different words, even if referring to the same change part type. Concerning this aspect, it has emerged that company's catalogue is not yet defined in an appropriate way, since a proper structure and terminology to be implemented in defining parts have not been officially established. Thus, it is currently characterized by some descriptions, that each technician introduces, according to some personally established parameters. This of course reveals to be an issue because, even though firm's machines are customized, it is undeniable that the starting point always lies in some standard groups. Thus, the fact that these ones are not univocally defined and depicted leads to a common working practice, where each employee arbitrarily decides how to deal with naming process, causing a general confusion when it comes to understanding how different change parts need to be defined and, above all, producing some major difficulties in tracking them again ex-post.

4.2 STRUCTURING OF EMERGED CRITICALITIES – *FMECA* DRAFTING

In order to detailly understand and analyse the emerged criticalities, with the aim of formalizing them through the means of a structured and officially recognized approach, the *FMECA* (Failure Mode, Effects and Criticality Analysis) model was applied to the just depicted scenario. This has allowed to specifically evaluate the impact that each issue has on the process, in such a way to define a priority ranking, according to which the company should intervene to improve current process flow quality and efficiency. Indeed, this methodology is aimed at ensuring the reliability of a process or product; this is specifically done by considering three main aspects: the identification and analysis of how the various parts of the system may potentially fail (failure modes), the description of the effects that these ones may have on it and the detection of a possible way to avoid and/or mitigate them. Briefly, it is a technique used to identify, prioritize and eliminate any potential failures from a system, design or process, before they reach the customer *(Franceschini, 2001)*.

Lacking a predefined and standardized format upon which to base this analysis, it was decided to adopt a specific one, showing all most important peculiarities for each critical aspect. Particularly, for each case, the following elements were highlighted *(Franceschini, 2001):*

- ID: criticality number and nature;
- Failure mode: detailed description of the criticality emerged from the "as-is" process state analysis;
- Effect: in-depth description of the effects it may cause, at the functional level and/or at the whole process one;
- Failure cause: analysis of the causes because of which the criticality might occur;
- Detection system: if present, description of the system used to prevent the issue, so that, in case it really occurred, it would be possible to immediately take awareness of it and activate a procedure to avoid/minimize its impact, before it reaches the final customer/user.

Moreover, with the purpose of assigning a score point to each issue, so that to determine its global and combined impact, three main parameters were considered *(Franceschini, 2001):*

- Severity (S): magnitude of the negative effects due to each failure mode, in case these ones really occurred;
- Occurrence (O): probability that the failure mode would really occur, if its related failure cause arose;

- (Un)Detectability (D): probability that, in case the failure mode occurred, it would not be detected by time, before causing a considerable damage for the business.

Each of these last three fields was evaluated on a scale from 1 to 10, with an increasingly negative connotation. Then, for each critical element, their product was calculated, with the aim of determining the *RPN* (Risk Priority Number); this one is seen as an indicator of the global and combined impact, at the process level *(Franceschini, 2001)*.

Finally, considering the results obtained from the *FMECA* analysis, *Pareto Chart* and *Risk Matrix* were also drawn, so that to graphically visualize the impact of the considered criticalities on the process and to spot the areas that mostly and more quickly need an improving intervention *(Franceschini, 2001).*

The *FMECA* table and these two graphs are reported in the Appendix, specifically in the section dedicated to paragraph 4.2, respectively as Table 4 and Figures 74 and 75.

5. IMPROVEMENT PROPOSALS

Starting from the obtained *FMECA* results, the issues of primary relevance were highlighted, and some improvement proposals were formulated in relation to these ones. Particularly, considering the choice of the criticalities to be focused on, for each of them, their global impact on the process was properly taken into account, together with the eventuality that, by decreasing it, it may also be possible to reduce the impact of a second problem, being highly connected to the first one. In making this choice, the precise needs that the company has in the short-term were also considered; these ones are tied to some aspects, which can be improved and made more efficient, in such a way to generate some major value in the medium-long run.

In the following, the criticalities which were decided to be prioritized are reported, by detailly analysing their problematic aspects, justifying the reasons why they were finally selected and proposing some improvements to tackle them.

5.1 QUALITATIVE AND QUANTITATIVE CONTROLS

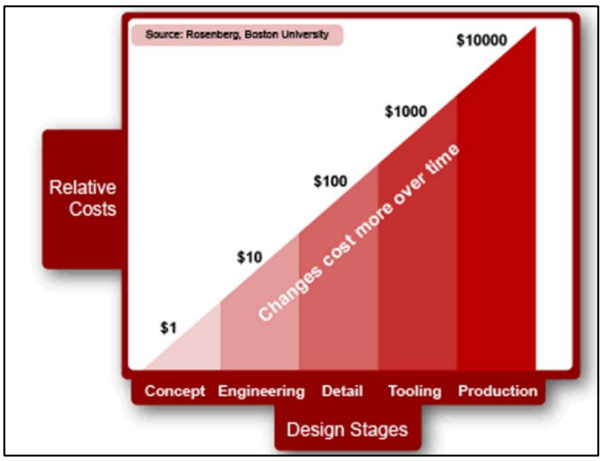
5.1.1 STUDY RATIONALE

Considering the results emerged out of the *FMECA* analysis, the issue showing the highest *RPN* value turned out to be the one related to product quality and quantity controls, which are currently performed at too advanced process stages. This means that any potential defects and/or missing parts are only detected closely to the assembly phase, when the company struggles in having these components available to go on with the last process steps.

Indeed, looking at the *Pareto Chart*, this one specifically suggested this criticality as the one which mostly requires some prioritized action, because of it corresponding to the highest column; therefore, it was decided to advance some improvement proposals concerning it. This choice was strengthened by also considering the *Risk Matrix*, where this issue figures in the yellow zone and even reveals to be one of the critical points showing the highest non-detectability value.

Detailly, when drafting the *FMECA*, an occasional frequency was assumed for this problem, because of the very high number of parts that are daily received, in relation to which only a small fraction finally reveals to be defective. However, the chosen severity value is significantly high, because if this issue comes true, its related impact will undoubtedly be particularly relevant. Indeed, especially for those parts which are primarily critical for process advancement, if these ones turn out to be defective or missing, and if this is only detected close to the process stage where they need to be used, this whole scenario will lead to highly significant delays and cost increase. It is known that if defects come up at early process stages, when the product is still being engineered, it will be easier to cope with them, since this one can still be adjusted and there is plenty of time to catch up. On the other hand, if mistakes are detected at more advanced process stages, especially if close to the final assembly step, their impact will inevitably be of greater intensity, in terms of both costs and time. This is due to the fact that, under this second scenario, machine's structure will have already been defined and produced and the available time gap prior to machinery final delivery to the customer will naturally shrink *(Franceschini, 2001).* This concept is represented by Figure 38.

Figure 38 Cost curve as a function of design changes (Franceschini, 2001)



Finally, this issue shows a significantly critical non-detectability value, which was given the highest score. Indeed, if the company continues to adopt its current quality/quantity control system, the same scenario will inevitably emerge: in case some parts turn out to be defective and/or missing, it will not be possible to detect them by time, thus the previously mentioned effects will naturally arise. In other words, considering firm's current quality/quantity control system, any potential non-conformities always emerge at too advanced process stages.

To better analyse this aspect, it is useful to detailly describe the current management procedure that the company adopts to deal with quantitative and qualitative controls of produced parts. A first distinction needs to be made in relation to component/processing type; within each group, a second one is required between in-house and outsourced production. Detailly:

- Mechanical parts:
  - Outsourced production: quantitative control is executed in the Warehouse, where parts are unloaded and individually scanned. On the contrary, an official phase entitled to qualitative control is missing;
  - In-house production: quantitative control is executed in the Warehouse, where parts are unloaded and individually scanned. From a qualitative perspective, parts are controlled by production units while being processed, but an official quality control phase, once they are received in the Warehouse, is missing;
- Metal sheet laser cutting (always outsourced): a quantitative control phase is missing, since, once parts are delivered to the Warehouse, they are unloaded by scanning the whole pallet; therefore, quantitative control is informally entitled to external suppliers. An official phase dedicated to qualitative control is also missing;
- Plane plastics (outsourced production rarely occurs; most of the times, they are internally produced but in the external site): the scenario is the same of the one depicted for metal sheet production.

5.1.2 PREMISES

Even though the focus of this first improvement proposal lies in facing the delay in detecting qualitative and/or quantitative failures, it is also interesting to consider the other side of this aspect. Indeed, company's delay in getting aware of production non-conformities contributes to worsening another issue. This one would anyway exist, even in the case of failures being on time detected, and it consists in the fact that the greatest majority of defective and/or missing components is represented

by the ones which are produced in-house but in the external site. Clearly, if these problems raised at an earlier process stage, their effect could be limited, but, in principle, they would anyway occur. Thus, considering that an official quality/quantity control phase is missing in both scenarios, but focusing on the fact that, if compared to those change parts being produced in the headquarter, the ones coming from the external site usually show an higher defect rate, it can be concluded that production flows being carried out in this other site constitute another relevant issue, which can be considered as a secondary cause, worsening the specific criticality first analysed in this paragraph. Therefore, the proposal of improving production management and efficiency for these external flows could be a way to further reduce the frequency according to which the first issue occurs, still knowing that this one anyway needs an optimized handling system to minimize its severity and undetectability.

To better understand how this second criticality relates to the first one, by intensifying it, it is important to detailly depict its key features. First, production flows in the external site turn out to be problematic because of several different aspects, which are all related to it being poorly controlled and not efficiently managed and which have already been detailly described in paragraph 4.1.7. To exemplify this problem, a peculiar and recurring situation can be pointed out: if some major issues occur, the employees entitled to plane plastic production directly ask for clarifications and solutions to the ones that have drawn the problematic components, even though they cannot be fully aware of what is going on in the production steps following theirs. This leads to a major discrepancy, concerning competence allocation and production flow visualization, which in turn causes a precise consequence: on one side, change parts produced in inside Machining Department are precisely and continuously tracked, while, on the other side, plane plastics show some key deficiencies in this sense. Therefore, organizing this site's spaces and managing its production in this way of course increases the possibility of incurring into some qualitative defects and, particularly, into some missing or mixed-up parts.

So far, it has been highlighted that the criticalities concerning the external production site worsen the ones related to the delay in detecting any non-conformities. However, it needs to be noticed that this reasoning can also be oppositely applied. Indeed, the kind of production logics characterizing the secondary site show some relevant limitations, but these ones are aggravated by the type of part depositing in the Warehouse. In other words, on one side, considering the current organization of the external site, an increase in the frequency of non-conformities is detected; on the other one, the actual part depositing system leads to a scenario where, if these qualitative and/or quantitative failures really occur, it will almost be impossible to get aware of them, until the pallet containing them is finally unloaded, closely to the final production step. Therefore, focusing on secondary site current management, not only a proper failure detection system is missing, allowing for the problematic parts to be detected in a useful time to minimize their impacts, but these ones are even carried about almost until the end of the production flow. In fact, it is not a chance that these two considered criticalities have been introduced in the *FMECA* among those ones showing the highest non-detectability value.

In conclusion, after having exhaustively explained why and how these two problematic aspects are closely connected, it can be stated that, in trying to decrease the impact related to quality and quantity controls, it may be useful to improve external site management too. In this way, two process aspects could be simultaneously optimized in a single action. This consideration has finally further strengthened the choice of prioritizing the first considered criticality as an improvement target.

5.1.3 IMPROVEMENTS

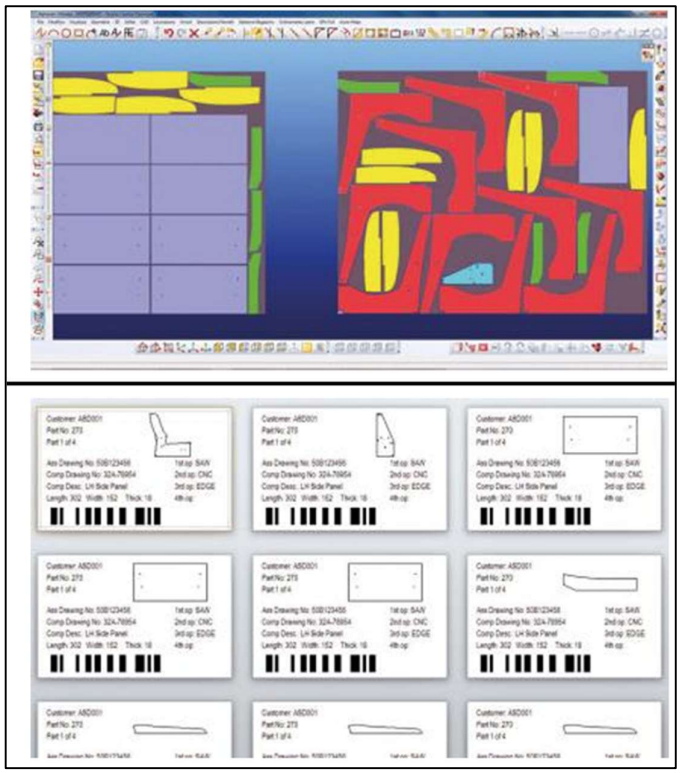
While analysing this scenario, it straight emerged that overcoming process current deficiencies and failures represents an optimal starting point to face and solve the just depicted criticalities.

5.1.3.1 PART DEPOSITING IN THE WAREHOUSE

With the aim of specifically addressing the first described problem, it is needed to completely revise plane plastic and metal sheet unloading system in the Warehouse. This constitutes a first improvement action to significantly reduce all three parameters reported in the *FMECA* table (S, O and D). Detailly, this solution reveals to be quite simple to be implemented: after having detected that the current procedure is somehow inefficient, an immediate solution simply consists in approaching it in the opposite way. Therefore, rather than scanning the whole pallet, the single parts would be individually unloaded, so that to immediately identify any missing or clearly defective components. This new procedure would undoubtedly cause an increase in the time needed for component depositing in the Warehouse; nevertheless, thanks to today's technological systems, this increase can be considered to be almost negligible and, in any case, significantly lower, if compared to the extra-time that currently arises, whenever qualitative and/or quantitative defects are lately detected. Moreover, even though some cases occurred where this alternative procedure could not be applicable because of particularly large pallets, it might at least be implemented for the ones containing the most critical components, namely those ones that, if defective, would highly impact on the critical path, by considerably delaying it and ultimately causing a delay in the final delivery to the customer.

Furthermore, especially if considering plane plastics, this new pallet unloading system could already be practically and easily implementable in the short-term, since it may be supported and facilitated by a nesting labelling management software (see Figure 39), that the company already owns and that should only be officially adopted.

Figure 39 Software for nesting labelling management (Alphacam Quote)



Basically, this system can generate the information needed by machine supervisors to consequently support automatic or manual label printing. In the first case, the system generates a program, which is complete of label printing and application with respect to component positioning in the coordinates

of the nesting plane. In the second scenario, the program can be used in the operator-driven setting to visualize the nesting plane, then to properly select the required component and immediately print its related label. Label layout can even be customized, by using the information concerning the considered part, having previously been uploaded on *Alphacam*, the IT platform used for plane plastic nesting operations. By doing so, each component may be individually labelled, thus separately scanned when depositing it in the Warehouse, which could also preliminarily verify its key features *(Alphacam Quote)*.

Moreover, this aspect might be further facilitated, by implementing another application that the company already has: a software to visualize the labels of the parts that have already been deposited in the Warehouse. Whenever the barcode of the label previously stamped on a specific component is scanned, this system allows to visualize its enlarged picture, by also reporting any key information, that is collected by the hardware device from company's network, which it is connected to. Furthermore, this system can specifically track all previously produced and completed parts, by registering them in the system as "Loaded in the Warehouse", in such a way for them to be centralized and immediately tracked, if necessary. This procedure can even allow to close their production cycle monitoring, by activating a dedicated status in the *Order Management Module*, whose structure and functioning will be detailly analysed in paragraph 5.1.3.2 *(Alphacam Quote)*.

To sum up, the just described improvement, whose feasibility has been largely supported, consists in anticipating the quantitative control step, while also optimizing it. Indeed, if implemented, it would drastically reduce the probability of detecting any missing parts at too advanced process stages, by also contextually decreasing their impact, since these ones would occur at useful production steps. In other words, it would implement an efficient failure detection and prevention system, which would act by time, immediately upon product receipt, in such a way to detect any potential problems before these ones become too critical to be minimized.

5.1.3.2 EXTERNAL PRODUCTION SITE MANAGEMENT

Having previously analysed that an improvement in external production site management can be useful to avoid the just depicted criticality and several other related ones, some possible proposals have also been introduced concerning this specific aspect. Similarly to what has been described in the paragraph above, since a clear inefficiency exists in relation to the current management system, a considerable improvement can be obtained, by simply overcoming the actual deficiencies.

To reach this purpose, a first significant advance may be achieved by introducing some stationing bays for all produced components in the area close to the pantograph which machines them, to be specifically and clearly distinguished according to the order they belong to. Concerning this aspect, it may even be evaluated to further divide these waiting bays, by making a distinction between the ones entitled to the new machines and the ones destined to the components commissioned by the After Sales. In this way, part sorting could be facilitated and operators would have the absolute certainty that each of them is actually placed in its intended destination; by doing so, at the assembly step, they would be sure that, within each specific pallet, there are all - and only - the parts which are really needed for their related order completion.

In this field, another possible improvement action, which can be easily implemented in the short-term and which can support the just described one, lies in the official introduction of a system to have each specifically produced item labelled, thanks to the usage of the nesting labelling management system, whose usefulness has already been highlighted in paragraph 5.1.3.1. In this way, each component

would be properly registered and distinguished, in such a way to facilitate its subsequent tracking and to reduce the probability for it to be assigned to a wrong order *(Alphacam Quote)*.

Beyond this one, a further improvement to support this proposal consists in strengthening another solution that the company theoretically already owns, namely the customization of nesting report layout. Indeed, this one can be filled in with some key information, concerning part tracking and identification, in relation to their reference machine. Detailly: a specific letter univocally assigned to each order, so that to obtain a unique matching and coding for each pair; next to the picture of the nesting plane, a list of all orders being under the way, which are identified through their reference letter; on each component figuring in the picture of the nesting plane, indication of the letter assigned to the order which that part belongs to, together with its ID number for its related label identification *(Alphacam Quote)*.

An additional improvement proposal concerns the introduction of an official professional role, being specifically entitled to the direct organization and supervision of the operations being carried out in the secondary site. Indeed, the discrepancy between the internal and external sites arises because, within the headquarter, all flows are directly and closely monitored and administered. Therefore, even though an official qualitative/quantitative control step is missing, parts are at least better controlled by production units, with the consequence that any key criticalities tend to more frequently emerge. This represents another element supporting company's need to introduce a similar approach also in relation to those production flows being organized in the external site.

Concerning this aspect, it may be useful to reinforce the usage of the *Order Management Module*, which the company already owns. Indeed, since plane plastics are engineered in the headquarter but produced in the secondary site, it is not always possible to directly and physically control their production flow. Thus, the contribution of this system is undoubtedly precious, because it allows to monitor program and component advancement status from a back-office perspective. Specifically, this tracking system is based on status management and colour-code representation, as follows *(Alphacam Quote)*:

- Grey = IPT solid model still needs to be processed;
- Yellow = drawing in *Alphacam* format is under the way but still to "Validate";
- Orange = *Alphacam* drawing is complete of its technological solutions and "Validated";
- Green = part has been inserted in a nesting processing status;
- Rose = part has been partially machined, with respect to the required quantities;
- Purple = part has been fully machined, with respect to the required quantities;
- Blue = part has been delivered to the Warehouse, in the required quantities.

Moreover, production management and monitoring in the external site can be further facilitated and supported, by strengthening the already planned machine interconnections. Specifically, these ones are allowed to be configurated with the centres they belong to and executed program monitoring is activated, with the aim of virtually controlling production advancement status from *Alphacam* setting *(Alphacam Quote)*.

To sum up, by improving external production site efficiency, the company could reduce the criticality related to quality and quantity analyses, because, even by (erroneously) maintaining the currently inefficient control system, thus a high non-detectability value, it would at least be possible to decrease the probability for some defective and/or missing parts to really occur. Moreover, this improvement would primarily help the secondary site itself, by significantly reducing its criticality. Indeed, the frequency of incurring into some non-conformities may be lowered and a management system would

be adopted to significantly improve the probability/capability of detecting any possible issues and facing them by time. This would allow to move this critical point in the Risk Matrix, having it enter the non-risky green area.

In conclusion, the choice of dislocating some major productive flows in an external site does not constitute a problem by itself; it becomes such only in case this site management reveals to be superficial and not directly controlled by the headquarter. By simply improving this aspect, it would be possible to almost nullify its related criticalities, only maintaining the limitation concerning transport costs. However, in this case, where the external site is located in the neighbourhood of the headquarter, these ones do not even constitute such an unaffordable burden.

5.1.3.3 OFFICIAL QUALITY CONTROL POINTS

To complete the dissertation concerning this first improvement area, it is needed to also evaluate some possible actions to be implemented at the qualitative level. Indeed, in the paragraphs above, most of the introduced ideas concerned control optimization from a quantitative perspective. Nevertheless, another key problem was initially detected, in relation to the lack of an official quality control step.

In fact, by improving production management and efficiency, the company could reduce the probability of incurring into some defective parts. However, some inaccuracies may always occur, and the risk connected to externally purchased components would still be high. Thus, with the aim of reaching a condition of "zero-defects" at the assembly step, another required improvement action has spontaneously emerged: the introduction of a dedicated step and professional role, specifically entitled to produced and bought component quality controls, immediately following their receipt in the Warehouse. Clearly, this choice would cause a cost increase, but it would allow to be sure that, upon process start, all necessary components show an adequate quality level.

Specifically, this proposal could be optimized, by implementing the technological and IT solutions that today's state-of-art offers. For instance, some machine vision systems may be used, in such a way to automate these controls, allowing for them to be quicker and simultaneously carried out with high-level precision and accuracy. In this sense, these devices could be applied to technical drawings, considering the requirements and indications they report, so that to extract from them some basic rules and criteria and to detect any inaccuracies and/or anomalies at a higher precision rate, if compared to human sight. Detailly, two different approaches might be implemented in this field: traditional (rules-based) and deep-learning based ones *(Pekat Vision, 2024)*.

The first rely on predefined rules and algorithms to analyse images, by using techniques, such as edge detection, pattern matching, colour analysis and thresholding. The idea is that of selecting an appropriate set of features, then establishing some specific parameters that the system uses to evaluate whether an item meets all pre-defined quality standards *(Pekat Vision, 2024)*.

On the other hand, the second are a subset of machine learning and use neural networks with multiple layers to automatically learn features from data, thus excelling in complex and varied inspection tasks. Specifically, these systems can be classified in supervised and unsupervised methods. The first ones are trained on labelled datasets to extract text from pictures or to identify and classify images, objects or defects. The second ones are trained using only good images to identify any deviations from the norm, then using these ones to point out any defects (*Pekat Vision, 2024)*. Generally, these platforms can be particularly useful, since they do not only enable precise error detection but also allow for intelligent quality control and automated decisions. Indeed, a deep learning vision system is aimed at integrating AI across all process steps, by capturing raw data with the camera, implementing real-time processing of image data and automating decision-making process, in such a way to deliver

precise, reliable, fast, reproducible and scalable results for demanding industrial applications *(Basler, 2025)*.

Detailly, their typical workflow is organized into these main steps *(Basler, 2025)*:

- Image acquisition: the first step involves the machine vision camera capturing the raw image, so that to deliver high-quality image data;
- Image transmission: the following stage consists in image data being efficiently and loss-free transmitted to the processing hardware;
- Pre-processing: in this phase the image is optimized, so that the deep learning software can then use some AI models to deal with data control, configuration and analysis;
- AI inference: in this core step of the procedure, the CNN (Convolutional Neural Network) model analyses the image and makes a decision, in such a way to deal with error detection, faulty components and text reading. This is done by specifically processing the image captured by the machine vision camera in several successive layers, so that to extract some relevant features (shapes, edges or textures) and to classify, segmentate or recognize the object;
- Result transmission: in this final phase the previously obtained results are transmitted to the controller or to the higher-level system, so that to immediately make them available for downstream processes, such as sorting, quality control or process optimization.

In choosing which system to implement, several different factors need to be considered, including the complexity of the inspection task, data availability, cost, real-time requirements and computational resources. In general, traditional machine vision typically involves lower initial hardware costs but demands significant expertise in creating and managing rule-based algorithms; on the other hand, advanced deep learning requires higher initial costs but significantly reduces the time needed for training neural networks, thus automating the process and allowing employees to focus on other tasks, once data is provided. In many cases, the best choice consists in integrating both systems to leverage on their respective strengths, so that to ensure high accuracy and efficiency in quality inspection. Indeed, this hybrid strategy can lead to more robust and effective inspection systems, then improving product quality and production efficiency *(Pekat Vision, 2024)*.

In conclusion, this improvement proposal's relevance is strengthened by current social and educational context, whose major issues have already been described in paragraph 4.1.9. Therefore, considering this scenario and focusing on company's need to closely stick to some specific and precise tolerances when producing its machinery, it turns out to be fundamental to plan an official quality control phase. As initially explained, this one would be entitled to specifically and immediately verify produced and purchased parts' measures with respect to their initial drawings and/or specifications, in such a way to handle any necessary re-processing operations by time.

5.1.3.4 STANDARDIZED OFFICIAL ASSEMBLY PROCEDURES

Finally, an improvement proposal has been advanced to address final assembly phase management, with the aim of also improving this production step, in such a way to prevent any possible mistakes even from this viewpoint and to avoid any reductions in finished product quality. Indeed, while analysing process efficiency at the actual state, it emerged that the company has not adopted any official, standardized and formalized assembly procedures yet. On the contrary, this step is still only and totally based on technical drawing manual interpretation.

Considering this aspect, an idea emerged and was introduced to the executives to be accounted for. This one consists in using the AI to prepare some assembly guidelines and some official flowcharts,

so that to dedicatedly show, specifically for each order, the step-by-step sequence of actions and decisions to be carried out at this stage. Detailly, these tools could show which components need to be assembled, how this is to be made and which is the specific sequence to be followed. Moreover, the aid of AI platforms in this phase would allow to compensate for the currently missing procedural indications, by converting 3D CAD files and 2D technical drawings into step-by-step instructions, being more easily readable and interpretable, and into flowcharts, graphically showing the logical assembly sequence, enriched by some animated presentations and scripts *(Simeone A.).* In this sense, the easiest solution, which could already be applied in the short run, thanks to some free AI platforms, such as *Google Gemini* or *ChatGPT*, consists in uploading 2D technical drawings in PDF or PNG/JPEG format. By doing so, through these platforms' vision systems, it may be possible to have these documents be analysed and interpreted, in such a way to provide a component list, also describing their assembly sequence and identifying their potential ambiguities.

The proposal of using the AI in this field was only introduced from a theoretical point of view, because it generally constitutes an action to deal with overall machinery production, including change parts, but not being specifically focused on this component type management only, which is this thesis' precise purpose. In other words, it was analysed as an interesting way to further improve change part management, but, considering its broader application field, extended to the machinery in its entirety, its practical experimental evaluation and application was left to the company to be performed in the future. Anyway, this kind of AI software application was indirectly tested, since it was largely and practically applied to another field, that will be exhaustively and detailly investigated in paragraph 5.4. This one concerns the analysis of bottle/capsule/wire-hood sample technical drawings through the AI *Google Gemini* platform, with the aim of speeding up sample verification and the subsequent choice of the change parts they need. As it will be specifically explained when dealing with this other improvement area, the system revealed to be precise, accurate and reliable in analysing technical drawings and then extracting all necessary data from them. Considering that in this case a different typology of drawings is concerned but the logic to be implemented is always the same, an analogous result is then expected, to be considered as a support for this proposal's adequacy.

Another easily implementable solution is that of filming an experienced assembler while working on a specific machine, so that to make this video available to help less skilled operators, thus facilitating and optimizing their performance. Starting from this, the usage of some dedicated IT systems could further amplify this method's functionalities, by converting videos into some written and well-structured procedures. An even broader aim might be reached by exploiting artificial vision systems, specifically by installing some video cameras to monitor the working area and to compare what is being done by the operator with what is shown in the technical drawings. By doing this, a continuous feedback loop would be activated, so that to notify any anomalies in real time and to automatically generate some immediate corrective instructions, to be structured into some dedicated flowcharts *(Simeone A.).* Moreover, thanks to augmented reality and through some viewers or projectors, technical drawings' information could even be superimposed on physical components, so that to clearly and precisely show where parts need to be inserted *(Curry G.L. & Feldman R.M., 2011)*.

In conclusion, these assembly-related improvement proposals can optimally be introduced in Industry 5.0 industrial paradigm, since they closely satisfy the request and the exigency of making the human factor increasingly relevant, enhanced and centralized (*R. Stark, G. Seliger & J. Bonvoisin, 2017)*. Concerning this aspect, a study carried out by *Politecnico di Torino* showed that AI usage to support product assembly phase can really facilitate the introduction of neurodivergent, dyslexic or dyscalculic people into some diversified industrial contexts. Indeed, these platforms can automatically generate some clear and simplified flowcharts, so that it is possible to straight

schematize any logical sequence and facilitate its subsequent visualization. Then, this allows to solve, or at least to minimize, the difficulty that some people have in structuring their actions and/or in interpreting the given instructions *(Simeone A.)*.

5.2 CHANGE PART FORMALIZATION

5.2.1 STUDY RATIONALE

While analysing the actual process state relative to the management of the samples sent by the customer, with the aim of evaluating, engineering and producing the necessary change parts to handle them at best, an important criticality emerged. This one has already been introduced in paragraph 4.1.12 and consists in the whole process being flawed by a general confusion, concerning the official and complete list of all change part kinds to be considered when producing a machinery. Moreover, it turned out not to be always clear how these ones need to be distinguished and paired, according to machine specifications and to the product formats they need to process.

By observing the *Risk Matrix* prepared starting from the *FMECA* analysis, it is to be noticed that this criticality figures in the red zone. Indeed, even though the severity of its effects is relatively restrained, the frequency according to which this issue occurs is particularly high. Focusing on the detection probability, it was noticed that some tools, such as the Handbooks for machine usage and maintenance, can be useful to compensate for this problem, by providing a first overall view of the change parts to be considered, whenever some confusion emerges concerning them. Nevertheless, if a clear and formalized list and description is missing, this problem can only be reduced, before it produces some considerable effects, but it will not be drastically solved, causing that it will continue to emerge at a high frequency rate. Therefore, it was decided to detailly face this issue, with the aim of finally and definitively preparing that change part documentation, whose need had strongly emerged.

Moreover, the necessity for this action to be implemented almost spontaneously emerged during my own internship experience. Indeed, this issue revealed as such when, considering the training program of a person just introduced to firm's reality, some difficulties emerged in explaining and then understanding all possible scenarios that can occur when dealing with change parts. Consequently, the need of clarifying this procedural aspect became a crucial exigency, essential for my own experience within the company.

Considering these reasons, a second improvement proposal was committed to drafting and filling an official and formalized change part database, so that to make all these aspects clear and visible. Specifically, this action was practically carried out and implemented during my whole internship path, in a step-by-step logic, and I was personally engaged in dealing with and finalizing it, by progressively integrating and specifying all relevant information.

5.2.2 PREMISES

Change parts are defined as components which are thought to be interchanged when implementing a format change. So, the word "format change" is used to refer to the variation of all those components that concern the handling, containment and processing of the products to be worked on the machinery.

Generally, most handling and containment components are common to several different machine and accessory types. For example, the infeed screws and the conveyors are used both on capsuling and wire-hooding machines. On the contrary, a different scenario occurs when focusing on processing parts, which are dedicated and customized, depending on machinery model and type. For instance,

rollers are only used when dealing with capsuling machines equipped with rolling heads, whereas wire-hooding heads are only used on wire-hooding machines.

5.2.3 CHANGE PART LIST DRAFTING

The official change part list is reported in the Appendix, in the section specifically dedicated to paragraph 5.2.3. It was enriched by some clarifications, needed to better understand how their usage changes, depending on the considered contexts.

Specifically, change parts were distinguished and organized into two families:

- General components: these change parts are the ones used to process bottles, thus being mounted on almost any machines and chosen and changed depending on bottle formats;
- Processing-dependent components: these change parts are the ones to be varied, together with the already mentioned general ones, depending on product processing type (capsuling or wire-hooding).

5.3 ENGINEERING-TO-ORDER LOGIC FOR ALL CHANGE PARTS

5.3.1 STUDY RATIONALE

By observing the *Pareto Chart*, it is clear that one of the criticalities with the highest *RPN* value is the one related to the sale of different change part types to process the same capsule/wire-hood format, which is worsened by the eventuality of even offering the customer some components being completely inadequate for the kind of product he needs to work on the machinery. Moreover, considering the *Risk Matrix*, it is to be noticed that this issue, which is due to sample-based production of these change part types, figures in the red area. Indeed, even though it occurs with a relatively moderate probability, whenever it finally comes up, the effect it will cause will be catastrophic. Furthermore, the severity of these consequences is enhanced by this criticality's non-detection probability, which is also particularly high and depicts a scenario where this issue is not usually detected, before it becomes considerably worrying. In fact, focusing on this problem's current management, the only way to immediately detect any clear failures and/or similarities with past orders just lies in operators' experience.

Considering the flaws related to this failure mode, which have already been detailly described in paragraph 4.1.8, some relevant concern has been perceived about them. Therefore, it was decided that also this critical point had to be deemed as an improvement target to be prioritized.

5.3.2 ENGINEERING-TO-ORDER PROPOSAL

Since the severity of this considered criticality is entirely due to the kind of capsule/wire-hood change part production process, which is a sample-based one, it was thought to advance the proposal of introducing an engineering-to-order logic, also for these component types. This improvement action simply strengthens a way of thinking that were already being developed within the company; this one consists in launching and pursuing in this field the same procedural iter that is already being followed when dealing with bottle change parts.

Detailly, this new management system requires to activate an engineering phase, also when handling capsule/wire-hood change parts, in such a way to straight adapt them to each order's specific measurements in a preliminary phase. Basically, for each machine, all change parts would be engineered from scratch, by starting from the delivered samples, then preparing some specific drawings and setting some parametric values, so that to already determine components' specific measures during production planning phase.

By adopting this system, operators would be sure that the change parts offered to work a specific capsule/wire-hood format perfectly fit it. Moreover, they would contextually have the possibility to create an official database, where the change parts produced for each specific capsule/wire-hood format could be formalized, by providing each specific drawing with a proper code. In this way, if a processing request were received, concerning a format being perfectly identical to another already processed one, operators would have the absolute certainty to offer the same change part, without even needing to start again its engineering phase, thus also avoiding activating sample receipt and analysis steps.

Furthermore, in achieving this purpose of database general reorganization, it may even be evaluated to define a sort of a drop-down menu, to be used when codifying different change part types and specifically concerning all their categories; this one would be enriched by some pre-filled fields, called “attributes”, which could detailly define the master data. By doing so, it would also be possible to improve the criticality that has been previously described in paragraph 5.2. Indeed, the proposal which is now being depicted would allow to define the master data in a standardized way, having the certainty that everyone uses the same language and extracting a complete and structured list of all existing change part types, also specifically showing how these ones need to be paired and used. This would even allow to facilitate their subsequent searching, because, by introducing some key attributes, like length and diameter, and then filtering according to them, it could be possible to easily find the drawings related to each order’s capsules/wire-hoods, to be used as a starting point for any new engineering work.

5.4 AI USAGE FOR SAMPLE ANALYSES

5.4.1 STUDY RATIONALE

The last improvement proposal tightly connected to process flow optimization has been advanced in the field of sample analyses aimed at order validation, which are currently made through manual technical controls. By observing the *Pareto Chart*, it is noticed that the *RPN* value associated with this criticality is not particularly high. On the contrary, focusing on the *Risk Matrix*, the scenario that comes out of it is significantly different, since this problematic aspect figures in the red zone. This is due to the high probability that this failure mode occurs, worsened by the severity of its effects, which is classified as a critical one.

The issues correlated to these tests (detailly explained in paragraph 4.1.4) encouraged the company to evaluate some alternative ways to deal with them. Moreover, this choice was strengthened by the kind of approach that the firm has always had in facing R&D proposals. Indeed, it is undeniable that the current sample testing procedure is not only problematic but also obsolete, since the industrial scene nowadays offers some alternative and more innovative solutions to perform these controls. These ones primarily concern the usage of AI platforms in this field; therefore, the company has positively evaluated the proposal of introducing them and I was personally involved in testing these alternative AI-based sample verification methods, in such a way to improve and optimize the just depicted aspects.

5.4.2 PREMISES

Considering what has just been explained, the fourth improvement proposal specifically consisted in using the artificial intelligence to support sample control execution. In this way, not only the company could be able to speed up these verifications and minimize their error rate, but it could also have the opportunity to innovate sample process from this perspective, by introducing some alternative

solutions, that would allow it to evolve and keep up with today's industrial directions and with current industrial paradigms' requests and expectations.

However, it is necessary to highlight a significant limitation of this alternative control methodology: it can only be implemented when performing bottle, capsule and wire-hood dimensional controls. Indeed, in practically applying this improvement to this field, the AI operates starting from technical drawings, by detecting all measures needed to evaluate the order, such as heights, lengths, diameters and capacities. On the contrary, some other aspects, like compatibility verification between shells and bottleneck-shape, are necessarily based on physical capsuling tests; therefore, they cannot be assessed by simply analysing a drawing, but they always require some manual controls.

Anyway, the accurate and reliable AI usage during dimensional control phase can be considered as a significant improvement by itself. Indeed, even though the company would still need to manually carry out the other sample verification steps, it could at least speed up and optimize all previous ones, and this would reveal as a first precious step forward. Detailly, not only the firm could get an advantage in terms of control execution time and accuracy, but it would also be able to adopt a digitalized sample testing procedure. This means that the order validation step would be based upon the analysis of sample technical drawings, thus allowing operators not to ask the customer to send any physical samples anymore, apart from those needed for capsuling tests only, if these ones require to be performed.

Thus, physical samples would only be necessary for final testing phase, considering that even the controls carried out during the engineering step may be executed starting from technical drawings. However, this aspect needs to be further discussed: on one side, almost all controls to be performed during the order validation phase not only allow to be executed starting from technical drawings, but they can also be committed to AI evaluation, because they are simply aimed at verifying sold change part adequacy; on the other hand, even though verifications which characterize the engineering step could also be carried out using technical drawings - which would anyway be an improvement, if compared to the ones currently performed with physical samples - they would still be highly dependent on human judgement. This scenario occurs because the first simply consist in a preliminary and general sample analysis, whereas the second are intended to support change part precise and detailed engineering; thus, they require a direct and accurate evaluation of some special conditions, that cannot be currently delegated to AI assessment.

Moreover, the fact that AI-based sample controls are inherently and naturally based on technical drawing analysis, rather than physical sample one, leads to some significant improvements and advantages for other process steps, which are closely connected to sample verification one. So, remarking that this new control system may even allow to benefit several other process steps and dimensions has been a strengthening factor in advancing this improvement proposal.

First, it could lead to some benefits from a logistic and organizational point of view. In fact, beyond AI usage to perform these analyses, just making the pre-sampling phase a mainly digitalized one can be considered as a first significant improvement. Specifically, this new procedure could allow the company to reduce its logistic burdens, which naturally arise if physical samples need to be received and sorted. Moreover, it may even minimize the problems occurring when these ones are lately sent and simplify box preparation step in the Warehouse, which has registered some key issues, while analysing process actual state.

Furthermore, the adoption of this system, which bases sample verification on technical drawing analysis, would also be valuable from a commercial and contractual perspective. Indeed, if the

customer ultimately sent, closely to final production phase, some samples being significantly different with respect to the technical drawings initially received in the preliminary phase, operators would at least be sure to be able to demonstrate that such an inconsistency is not attributable to the company, thus avoiding it to incur into some potential extra-costs. On the contrary, if controls are based on physical samples, the discrimination between the two groups cannot be so clear and evident. This is due to the significantly higher margin of potential mistakes or inaccuracies, that necessarily need to be accounted for when performing manual controls, and to the greater difficulty in proving obtained result validity, being these ones more heavily dependent on non-univocally defined external factors.

Lastly, this alternative procedure could allow to solve a third criticality connected to physical controls, specifically to tolerance interpretation. Basically, when tests are performed starting from physical samples, the customer just sends them, without providing any precise and univocally defined clarifications, concerning the reference value to be considered to calculate the allowed tolerance ranges. Consequently, it is not possible to surely determine how the recorded values are positioned within the enabled tolerance margins, causing the risk that change parts are engineered without any sufficient play. To make an example, it has already happened, in the past, that some important customers asked the company for some refunds, due to some production flaws, emerging because of some change parts that had been designed and produced without any adequate tolerance margins. These situations do not frequently occur, since the firm has a specific policy to always introduce some sufficiently flexible tolerance ranges, while engineering change parts. However, if controls were performed starting from the paper-based and documental sample version, this problem could be totally solved. Indeed, Mechanical Technical Office would have a precise and unambiguous indication of the value which the reported tolerances need to be applied to and could then specifically design the necessary change parts according to it, by surely stating in the commercial documents that all components were thought as including the maximum allowed play.

To sum up, the controls aimed at order validation can be innovated, first by basing them upon technical drawing analysis, rather than physical sample one, and then by also adopting the AI usage to support them. This would not only allow to specifically advantage sample verification step, but it would also favour the one before it, consisting in the activities related to the preparation of the material required by this one, as well as the process phases concerning the management of commercial relations with customers. Moreover, this improvement could be considered as an opportunity for the firm to innovate and further develop, by embracing the logic of Industry 5.0 industrial paradigm, which is aimed at making the industrial market segment increasingly resilient and human-centric, by relocating competences towards more value-added activities (*R. Stark, G. Seliger & J. Bonvoisin, 2017)*.

5.4.3 PRATICAL AI USAGE TESTS

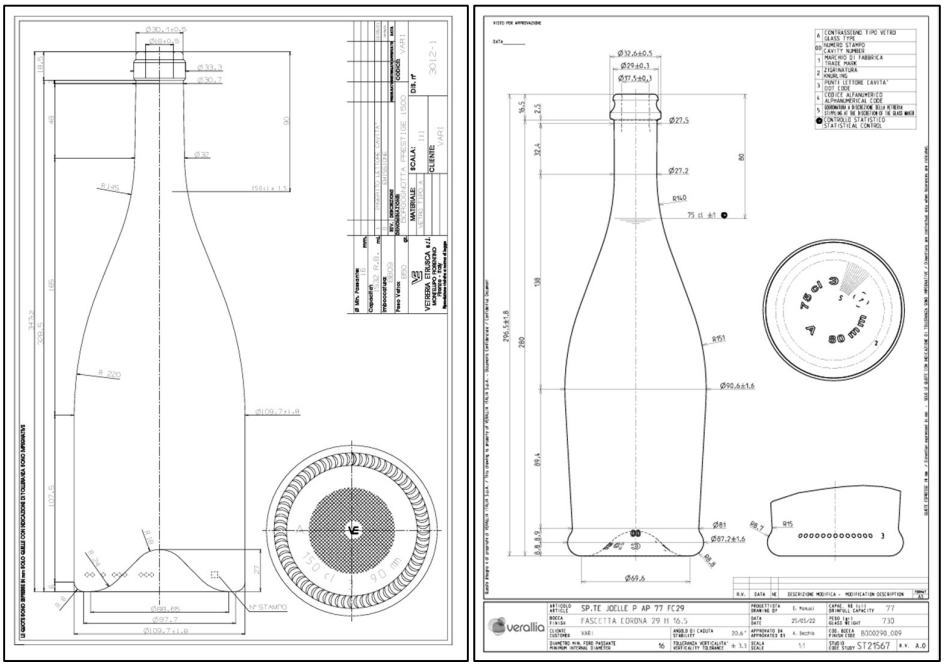
In the following, the procedure that was implemented to practically verify this solution's feasibility will be detailly discussed. As it has already been previously introduced, the starting point for the application of this new system consists in having the customer send sample technical drawings. Indeed, they represent the necessary condition for the AI to operate, which analyses them based on a prompt, containing all aspects that necessarily need to be considered in performing these controls and being integrated by technical drawings' PDFs. Particularly, it is necessary for the prompt not to be excessively specific; this means that the guidelines need to be precise but generalized, so that they can fit well any design formats, considering that their layout often changes, showing the measures reported in different positions.

5.4.3.1 BOTTLE ANALYSIS TESTS

FIRST ANALYSIS

The first tests have been performed starting from bottle technical drawings (see Figure 40), by comparing the results provided by the AI with those previously recorded by human operators, which were known to be correct. For each drawing, thus for each bottle format, the AI was asked to extract the following data: bottle type (conical, cylindrical or squared), capacity, maximum and minimum diameters, maximum height, intended use (product type) and cap type (screw, satin, mushroom, "T"). Detailly, concerning diameters, it was specified to report both maximum and minimum values in case of conical bottles, just the maximum one if considering cylindrical bottles and the longest side when dealing with squared bottles.

Figure 40 Example of bottle technical drawings. From the left to the right: a cylindrical and a conical bottle (Robino & Galandrino)



In choosing which AI platform to adopt, some tests were initially performed using *Qwen*. However, this one turned out to be poorly accurate in reading drawing specifications, particularly the heights, because of them being usually inserted too close to paper's left side to be clearly recorded. Therefore, some other tests were then carried out by using *Google Gemini,* which, on the contrary, straight revealed to be much more accurate and reliable, thus being chosen as the official one to be adopted.

The specific prompt that was initially uploaded to analyse bottle technical drawings can be found in the Appendix, in the section dedicated to paragraph 5.4.3.1.

While uploading the several different bottle files to be analysed, after having considered the mistakes made by the system, all key criticalities were progressively detected and investigated. In the following, they are detailly listed and described.

PDF reading: it has sometimes happened that PDF files turned out to be unreadable and not properly detectable by the system; this occurred because of their poor quality or because of bottle technical drawings being sideways inserted. In these situations, *Google Gemini* could not correctly read the necessary data, thus reporting no results or some incorrect ones, often extracted from some different

sources. Another issue concerning the analysis of the files provided in PDF format consisted in them containing some other documents, other than the technical drawing. In this case, it has sometimes occurred that the AI could not distinguish between relevant and negligible data, thus reporting some different results with respect to the ones specifically figuring in the drawing.

However, even though PDFs are characterized by the just depicted limitations, they reveal to be the most convenient documents for the company, since customers always send their product drawings in this format. Therefore, if these ones have an adequate resolution to be accurately readable by the AI, they represent the best drawing format for the firm, because they allow to be simply uploaded on the platform, without the need of previously converting them.

To handle and solve these criticalities at best, whenever PDF file reading turned out to be missing or inaccurate, a JPEG or PNG format was uploaded, which was simply obtained through a screenshot of the technical drawing alone. By doing this, the AI finally almost always returned the correct results. Considering this outcome, it was asked directly to the platform why this discrepancy sometimes occurred; the answer lies in format different nature and in the way the vision system interprets them. It was finally made clear that PDF formats often contain some different information levels: other than technical drawing picture, some metadata or hidden texts can be included, like incorporated text, tables or page headers, which may not correspond to the visualized graphics. This can cause some confusion to the platform, having it analyse some papers concerning conformity declarations or general specifications, rather than the technical drawing as such. Consequently, the AI may prioritize the coded text rather than the measure, by reading some misleading textual descriptions hidden in the file, thus reporting a theoretical value, which is different from the real one. On the contrary, JPEG or PNG formats are visualized as flat pictures, which are such that the platform makes a purely visual analysis, by detecting the technical drawing in the same way a human operator perceives it, namely with the measure lines, represented by the quotas with the arrows pointing at the numbers. By doing so, it does not incur into the risk of considering any information that may be referred to some other models, but it detects and straight reads some univocally defined values, which are clearly reported in bottle drawing *(Google Gemini, 2026).*

Being aware of this system's behaviour, with the aim of automatically handling these controls at best, two further clarifications were added to the prompt, which are explained in the following. First, for each uploaded file, in case of multiple documents containing both text and graphic elements, it is needed to absolutely prioritize bottle technical drawing, which is always contained within the file and represents the primary source for the analysis; this one is the document which data (measure lines, quotas, arrows, tolerances) needs to be drawn from, meaning that information cannot be derived from any other sources. Secondly, for each iteration, the uploaded PDF file needs to be analysed and, in case of doubt, no approximated values can be assumed; thus, in these situations, an error message needs to be generated to clearly state that, because of its poor quality and resolution, the uploaded drawing cannot be adequately and properly read and that no accurate results can be provided, then requiring the file to be uploaded again in JPEG or PNG format.

Result assumption: even though PDF reading problem was most of the times overcome by uploading a PNG/JPEG format, it has sometimes occurred that even this one could not be read in a completely correct way, because of some measures being too little, pixelated or ambiguous. To avoid the platform deliberately assuming some incorrect results, which operators could not detect unless performing a cross-control, another condition was added to the initial prompt. This one was implemented to make sure that this reading difficulty is immediately noticed, so that the personnel can get aware of it and manually intervene, in such a way to minimize the possibility of incurring into some transcription

mistakes. Detailly, it was specified that, even in the case of PNG/JPEG formats, if picture resolution is poor and some doubts arise, the platform cannot make any assumptions or interpretation attempts, but it must promptly signal the problem. So, in a broader perspective, the system is allowed to report some results, only if it is fully sure about them; otherwise, it needs to clearly point out its doubts and return final judgement to human operators.

Tolerances: since it was initially specified that the AI platform needs to report the tolerances to be applied to the quotas, it happened that, whenever these ones were not explicitly and clearly stated, they were arbitrarily assumed by the system, by using the ones figuring in the previously uploaded files as a reference point. This approach can be considered as an acceptable one, since allowed tolerances are largely similar to one another; however, with the aim of avoiding any potential mistakes, another condition was thought to be introduced, among the ones that the platform needs to comply with. Basically, this one explains that, whenever tolerances are not explicitly reported in the technical drawing, these ones simply need to be neglected, rather than deducing them; so, the system will show a message, clearly stating that tolerances were not shown in the uploaded file, and it will just return the nominal measurements. In this way, the operator can manually analyse and evaluate the specific case, checking whether there is any reference in the title block, which establishes to follow UNI norm convention concerning tolerances, or whether the drawing is defective by itself, because missing any information relative to this aspect.

Ambiguity in detecting bottle shape: sometimes, it has occurred that the system erroneously detected a bottle shape as a conical or cylindrical one, instead of correctly inferring the opposite. To deal with this criticality and optimize control accuracy, another condition was added to the prompt, which had not been initially clearly exemplified. This one specifically concerns measure detection and lies in just considering the side quotas, namely the ones external to bottle drawing borders and related to its profile/main body; this means that the ones concerning its bottom and neck can be neglected. Moreover, it was also clearly specified that a bottle needs to be classified as a cylindrical one if there is a single side quota referred to its exterior body; on the contrary, if two of them are reported, the bottle is to be considered as a conical one. Anyway, it was also specifically stated that, if bottle shape is ambiguous, the platform is required to signal this issue, rather than unsurely going on, by making some assumptions. An example of how to handle this procedure is provided in Figure 41.

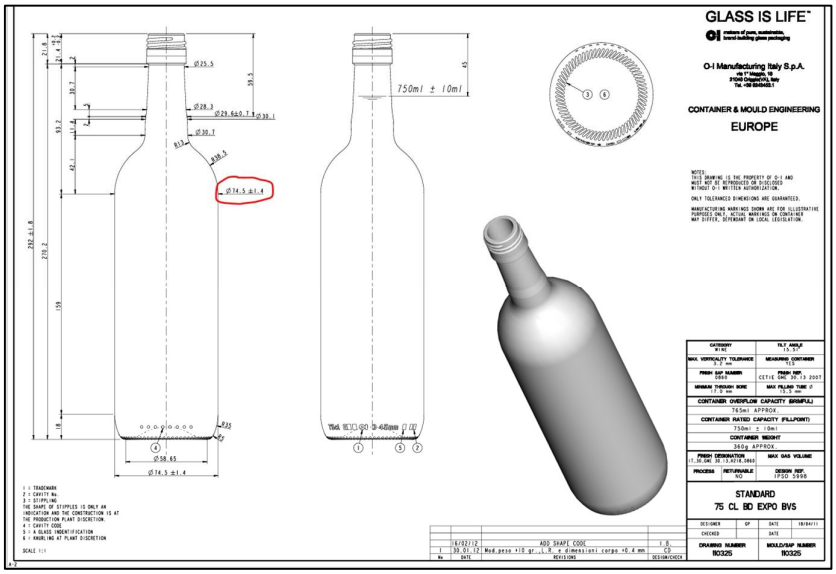
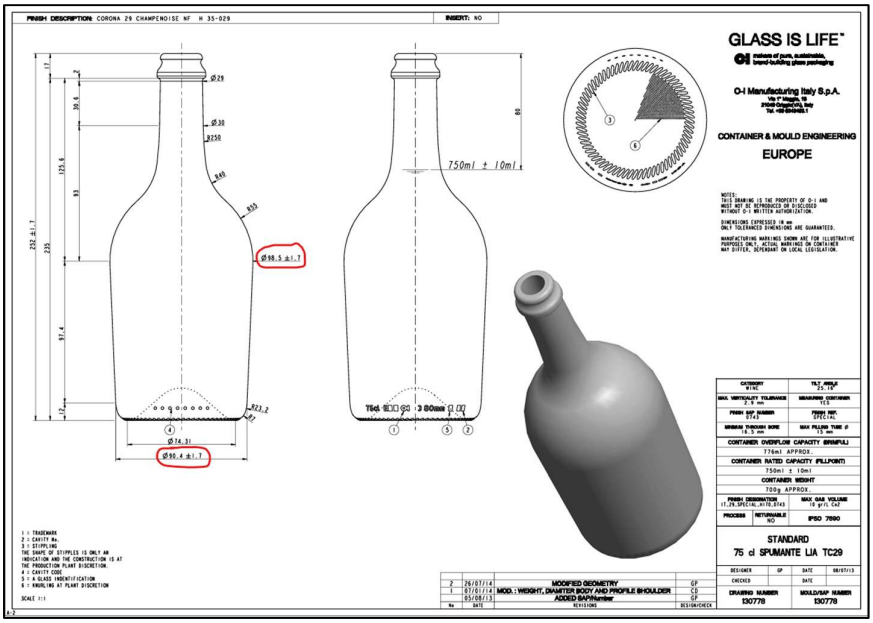
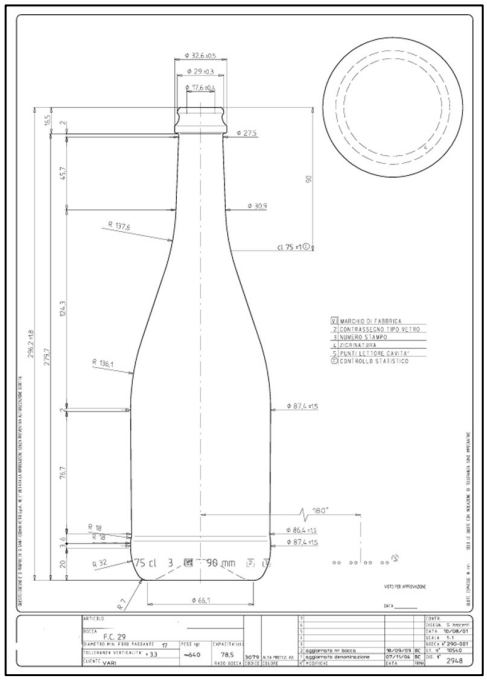


Figure 41 In red colour, an example of the diameter measures of interest: these are the ones external to bottle body, which are considered in their maximum value - and in their minimum one too, if the bottle is a conical one (Robino & Galandrino)



Special cases: a last condition was integrated, with the purpose of handling a special bottle format (see Figure 42), which had not been initially taken into account. This case can be described as such: when a technical drawing shows three diameters, being characterized by a minimal difference among them, one concerning bottle basis and showing the maximum value, another one immediately above it and showing the minimum value, and a last one related to bottle main body and showing the same value of the maximum one, which then keeps constant, then the bottle needs to be considered as a cylindrical one, thus only the maximum diameter is to be reported.

Figure 42 Example of a bottle being classified as a "special case" (Robino & Galandrino)



The table showing the results obtained from this first iteration can be found in the Appendix, in the section dedicated to paragraph 5.4.3.1, specifically in Figure 97. These highlight all emerged criticalities and mistakes, because of which the just described conditions finally had to be introduced in the initial prompt.

After having completed these initial tests and having investigated the necessary improvements they suggested, all additional conditions requiring to be implemented in the prompt were finally summarised, formalized and listed, as follows:

- Analysis block if the file is not clear enough: if PDF file is unreadable, the system needs to clearly state that "the drawing is not suitable to be analysed", then requiring that this one is uploaded again in a picture format (PNG/JPEG). Anyway, considering any format type, if any ambiguity arises that does not allow to return absolutely certain results, the platform cannot show any values, make any assumptions or use any data extracted from any standard databases or models, but it simply needs to signal that no accurate and reliable results can be reported, because of drawing's insufficient resolution;
- Absolute priority to the technical drawing: only those quotas that specifically figure in the drawing need to be considered;
- No assumed tolerance values: if tolerances are not explicitly written in the drawing, neither next to the quotas nor in the title block, they cannot be assumed; the system simply needs not to insert them, by just returning the nominal value, also clearly specifying that tolerances were not reported in the drawing;
- Priority to external side quotas: the measures needed in this phase, concerning order and its related change part validation, are just the ones referred to bottle main body/profile, not the internal ones, neither those specifying its bottom or neck dimensions;
- No shape assumption: in case of ambiguity between bottle visual shape and its reported measures, the system cannot make any assumptions, but it needs to ask for some clarifications, by pointing out its doubts, before going on with data analysis;
- Single quota: if there is just one side measure, referred to bottle body and external to it, then this one needs to be considered as a cylindrical one;
- Double quota: if there are two side measures, referred to bottle body and external to it, then this one needs to be considered as a conical one;
- Special cases: if diameter variation is minimal and limited to bottle basis, specifically to the label panel area, while its main body keeps constant, then the bottle needs to be classified as a cylindrical one and just its maximum diameter is to be returned.

These new rules were then introduced in a single prompt, embracing the indications to minimize any possible mistakes. Therefore, with the purpose of solving all previously emerged criticalities, the following step consisted in carrying out a second series of tests, aimed at analysing the same bottle formats, according to the just mentioned new comprehensive prompt. By doing so, the adequacy of the newly added conditions could be verified, so that to make sure that the system behaved in the planned way, by confirming the previously accurately detected data and correcting the initially wrong one.

The results obtained while performing this second step are reported in the Appendix, in the section dedicated to paragraph 5.4.3.1, specifically in Figure 98.

By analysing them, it was noticed that those bottle formats that had already been correctly interpreted during the first control set continued being subject to an accurate detection, also during this second

phase. These positively reported results showed system's general reliability, since they constituted the dominant scenario.

Moreover, considering those formats which had initially been characterized by some detection issues, it could be highlighted that they had lowered in number with respect to the initial tests. Indeed, the criticality concerning tolerances turned out to be completely overcome and the bottles labelled as "special cases" were noticed to be almost always correctly handled, except for one format only (Spumante Euro-Premium cl.75). In addition, most of the bottles whose specifications had initially been wrongly inferred finally produced some more accurate outcomes, thanks to the new prompt. Specifically, considering the ones whose PDF file was such not to be correctly readable by the system, it could be said that, in most cases, this last one correctly stopped, by pointing out drawing inadequacy and by requesting PNG format, which was then properly analysed.

Despite significantly lowering this control system's criticality, during this second iteration, some formats finally revealed still being problematic in some of their aspects, leading to some improperly detected measures. Moreover, it still sometimes occurred that, in case the system could not read the PDF file, this one went on, by extracting some data from external sources or from previously uploaded drawings, instead of generating the agreed upon error message. Specifically, if these ones are compared in number to the plurality of examined bottles, it can be highlighted that, in most cases, the system was able to correctly read the PDF file; moreover, considering the situations where this one had an insufficient resolution, it can be inferred that those scenarios in which the platform promptly and properly signalled the issue were higher in number, if compared to the ones when it erroneously went on. However, since some inaccuracies still emerged, it was thought to try further minimizing them. Thus, the prompt was increasingly refined and optimized, obtaining a final and definitive result, which is reported in the Appendix, in the section dedicated to paragraph 5.4.3.1.

By doing so, a third and a fourth iteration were carried out, by just analysing those bottle formats, which had still been improperly detected during the second control step. The finally obtained results are reported in the Appendix, in the section dedicated to paragraph 5.4.3.1, specifically in Figure 99.

By analysing them, it could be concluded that the issue concerning PDF formats turned out to be basically overcome: in those cases where the PDF revealed to be unreadable, the platform correctly behaved, by pointing out the anomaly and by requesting the PNG/JPEG format. Therefore, a single criticality still characterizes this control system: it may happen that, if also drawing's picture format has a poor resolution, the system reports some incorrect data, despite the rule of properly stopping, by clearly generating a message error, stating the difficulty to extract any accurate results. Since this criticality is specifically due to the quality of the uploaded drawings, it finally turns out to be more difficult to be faced. Moreover, if it really occurs, it will be more difficult to detect and become aware of it, in such a way to consequently intervene. Indeed, even though bottle formats are uploaded one at a time, if the system returns an incorrect result, without specifying that this one may not be reliable and accurate enough, it will be particularly complicated for the operators to notice it. Anyway, the frequency according to which this problem arises turned out to be relatively low, thus comparable to human error risk, maybe even lower.

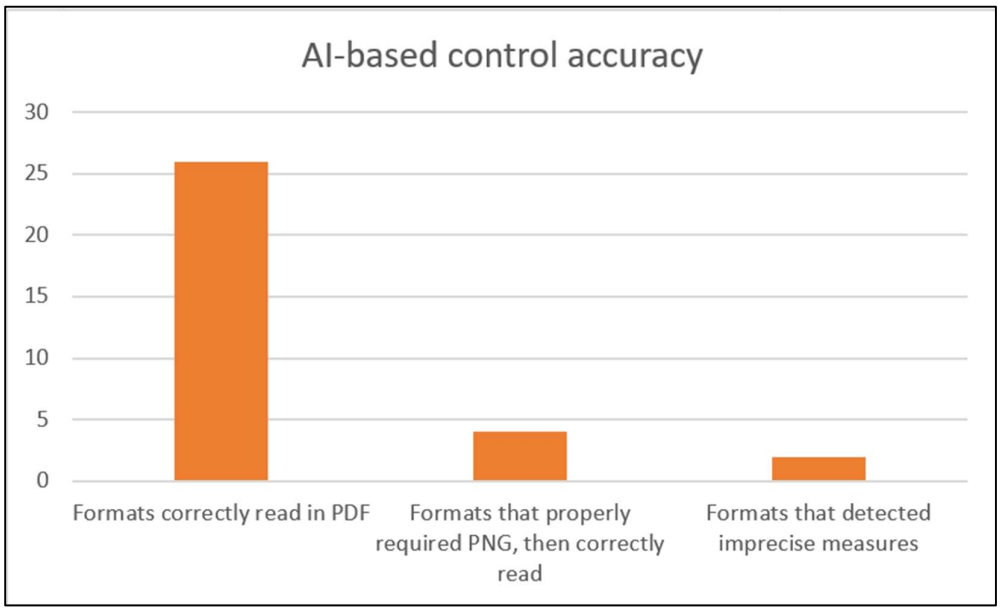
Nevertheless, with the purpose of minimizing this issue, an improvement solution was also proposed in this perspective. In fact, it was noticed that, whenever some mistakes occurred, these ones had previously been anticipated by the system requiring the technical drawing in PNG/JPEG format, stating that it could not read it in the PDF one. Differently explained, it almost never happened that the arisen mistakes were straight made while analysing the PDF file; on the contrary, considering

those cases that finally turned out to be problematic, it was noticed that, before making any detection errors, the platform had already asked for the drawing to be provided in an image format, judging the PDF as an unreadable one. Thus, this request can be interpreted as a flag, signalling that the considered bottle format is not necessarily problematic, but surely more critical to handle. Consequently, in order to generally nullify the error rate, a manual control can be made, just based on the specific cases where the AI requested the image format. Indeed, since almost all mistakes are included within these more complex cases, just making a cross-control specifically considering them can naturally increase the probability of being able to detect any problematic aspects. In this way, the company would be able to maximize analysis accuracy, also simultaneously minimizing human intervention; in fact, operator's personal aid would only be required and contemplated when dealing with the subgroup of those cases for which an image format was requested, one that constitutes a relatively bare set, if compared to the overall quantity of bottle formats to be analysed.

Moreover, with the purpose of avoiding incurring into this issue straight from the beginning, it could be evaluated to introduce some specific contractual clauses for the customers, defining some adequate qualitative standards, which technical drawings always need to comply with, in such a way to facilitate their reading and avoid any inaccuracies at the head.

To detailly analyse what has just been qualitatively described, in Figure 43, the results characterizing the outcome of the iterations carried out during this first test are further graphically investigated.

Figure 43 AI-based control accuracy - results from the first test



It can be noticed that, in most cases, the platform correctly returned the necessary specifications directly from the PDF format. Only with a lower frequency, it required the PNG/JPEG one to properly extract the required measures. However, simply requesting the drawing in an image format does not represent a problem by itself because, in most cases, whenever the system was not able to read the PDF file, it correctly asked for the alternative format, with this one then being accurately read. Thus, the only issue lies in those cases where some incorrectly detected values finally emerged, but these ones occurred with an even lower frequency, equal to 2 cases over 32.

So, only two cases turned out to be problematic, with respect to the thirty ones being correctly handled. Concerning these last ones, only 4 over 30 required uploading the PNG/JPEG format to get

an accurate drawing interpretation. Moreover, the two emerged mistakes were made starting from the file in an image format. Therefore, the system had already initially detected these two drawings' higher criticality, communicating that the PDF file could not be read and requiring the PNG/JPEG one; this means that, if operators had just manually analysed the few cases where the platform required this alternative format type (6/32), they would have promptly found these two considered inaccuracies.

With the aim of exploiting AI potentialities and functionalities at most, so that to increasingly accelerate sample analyses and allow for a better resource allocation, this control system was applied not only to measure detection, but also to the pairing of the most appropriate bottle change part type, specifically for each format. Therefore, after having verified the results obtained from technical drawing analysis and having proven their accuracy with respect to the target values, the request was made to automatically generate a table, to be formatted to be exported on *MS Excel* and filled in with all previously analysed specifications, for each bottle type. After that, together with control outcomes, another input was uploaded, namely the file specifically describing all rules and conditions to be considered when dealing with sample analysis, with a particular focus on those according to which the number and type of necessary change parts need to be determined, depending on sample specifications. In this way, another request was made to match each bottle format with its necessary change part type, including all obtained results in the just mentioned table. The prompt that was written to reach this purpose can be found in the Appendix, specifically in the section dedicated to paragraph 5.4.3.1.

The obtained results showed that *Google Gemini* AI platform is completely reliable and accurate in dealing with this other process step, choosing the necessary change parts in the same way as human operators entitled to these analyses had previously manually done. These outcomes are detailly reported in the Appendix, in the section dedicated to paragraph 5.4.3.1, specifically in Figure 100.

SUBSEQUENT ANALYSES

With the purpose of definitively testing AI reliability in handling these two steps of the order validation process – dimensional controls and bottle change part determination – and with the aim of further strengthening the proposal of practically implementing this new system, some other tests were carried out to process some new bottle formats, to be evaluated in relation to some other projects that the company had already managed in the past.

The followed procedure was the same of the one that has already been depicted in the lines above: the files containing bottle technical drawings were uploaded on the platform *Google Gemini,* also providing the optimized and definitive prompt, previously obtained as the result of the iterations that had been carried out during the first test. Once all new bottle formats had been processed by the platform starting from the input data, the obtained results were compared with the ones that had already emerged from the manually executed tests, which were known to be the correct target. Once the adequacy and accuracy of the specifications detected by the system had been verified, the platform was also asked to determine the necessary bottle change part types.

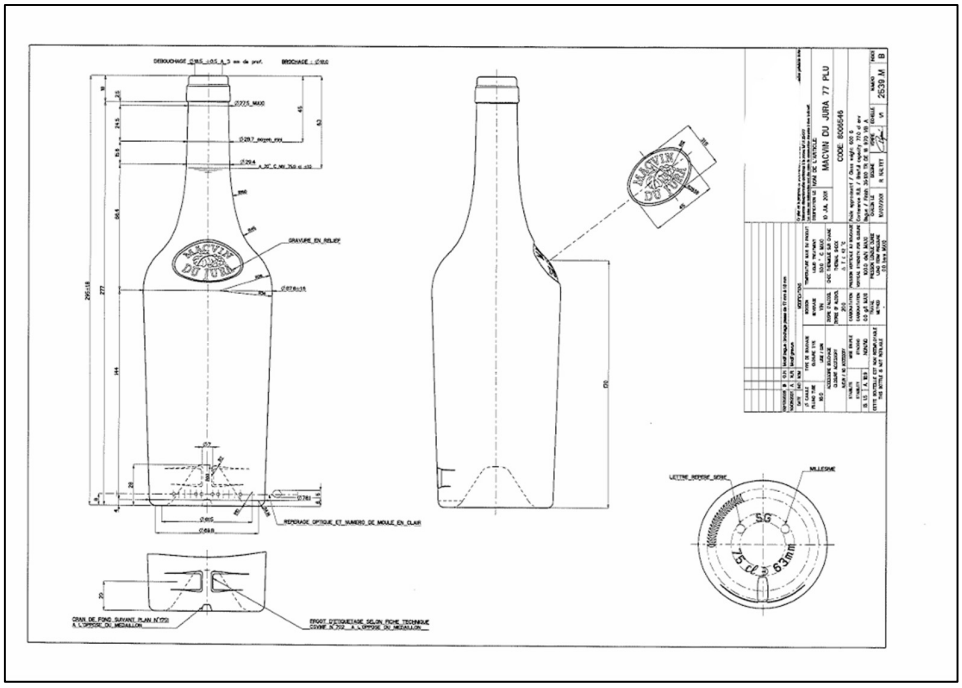
These results can be found in the Appendix, in the section dedicated to paragraph 5.4.3.1, specifically in Figures 101-110.

Finally, they turned out to be analogous to the ones obtained during the first test. Indeed, concerning the determination of the most appropriate bottle change part types, the AI confirmed its total accuracy and reliability. On the contrary, focusing on measure detection, the only emerged criticality was again

the one related to the occurrence of some imprecisely detected measures, with these last ones being anyway reported by the platform, rather than having this one generate an error message, clearly stating the impossibility of showing any accurate results. Anyway, as it has already been previously highlighted, this issue arises with a limited frequency and is only due to technical drawings' graphics. In fact, if considering the second analysed project, whose ones had a particularly high quality, the AI software showed total precision, since it did not make any reading mistakes, being able to accurately and precisely interpret all quotas.

To definitively prove that reading precision and reliability only depend on technical drawings' graphic quality, a further analysis was carried out, by deliberately choosing the case of a project, whose drawings had some pixelated and small quotas, being of difficult interpretation (see Figure 44).

Figure 44 Example of a technical drawing with a bad-quality resolution (Robino & Galandrino)

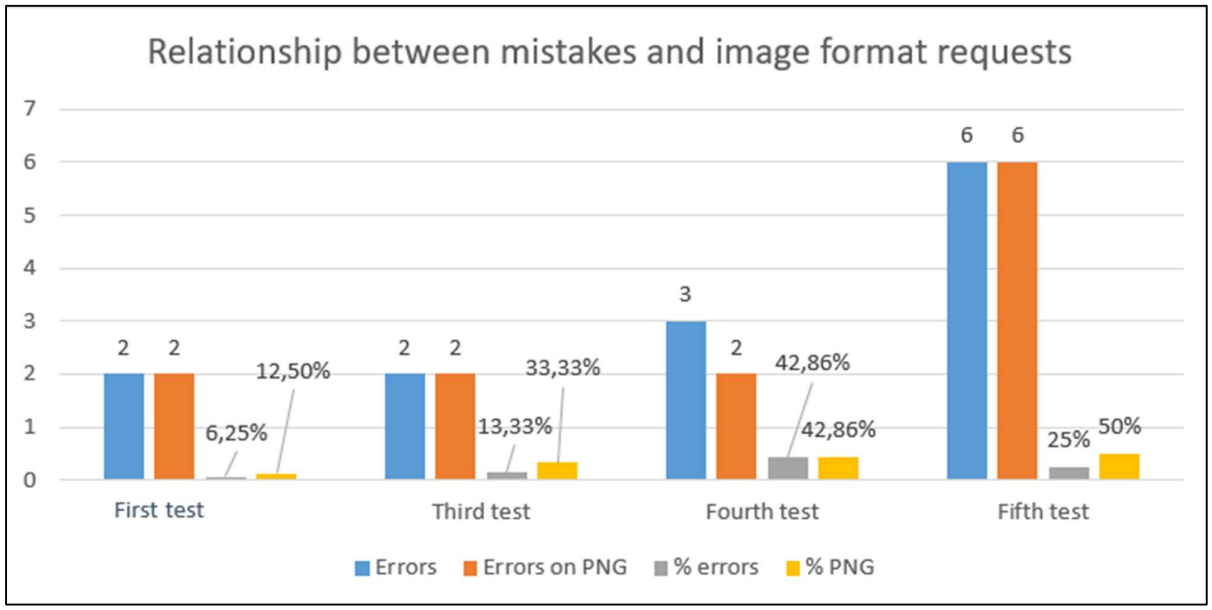


The significant increase in the error rate with respect to the previous tests confirmed that the mistakes made by the AI platform are only due to some bugs, specifically correlated with some critical files and/or with the poor quality of the technical drawings contained therein. Thus, even though the system cannot signal the potential anomalies by time, before making any mistakes (with this behaviour representing the best-case scenario), this failure is anyway easily avoidable at head. Indeed, since it only depends on drawings' quality, it is enough to make sure that these ones only figure within each uploaded file and that they have a high-resolution level; these conditions are necessary but also sufficient to guarantee result correctness. Indeed, it was noticed that some additional and irrelevant documents are often inserted within the files; however, these ones risk making some major confusion, thus complicating the analysis, without even adding any relevant information, since all data needed to deal with these controls can be derived from the technical drawing itself, without the need of consulting any other sources.

Moreover, it was again highlighted that, in almost all cases, the mistakes were made when performing the analysis starting from the drawing in an image format, after the system had already declared PDF unreadability. For instance, if considering the fourth executed test, which is the first one in order of

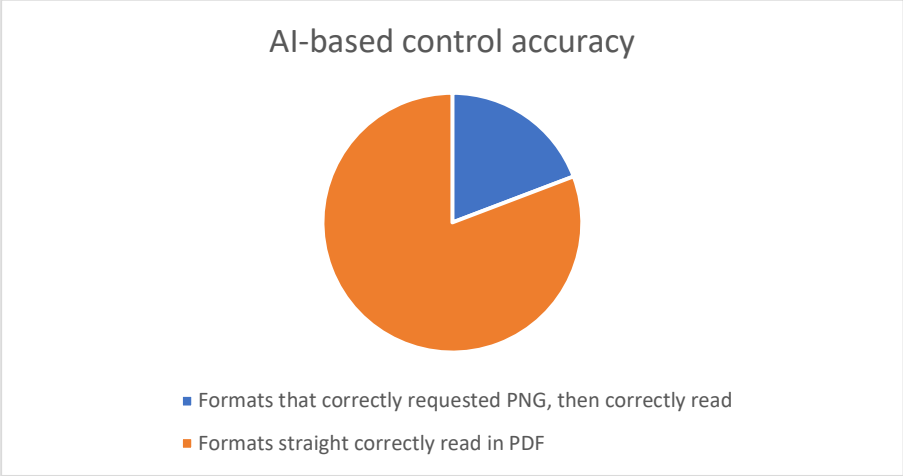
error rate, it can be stated that all reading inaccuracies made by the system occurred when analysing the PNG formats, after the platform had already initially pointed out the criticality of the related PDF ones. Therefore, it can again be stated that the request of sending technical drawings in PNG/JPEG format can be reliably interpreted as a flag, showing the eventuality that the analysis will be a critical and more difficult one; this scenario can then suggest that some inaccuracies may possibly arise, thus facilitating error detection and tracking. Indeed, if the drawing is provided within an adequate PDF file and has a high-quality resolution, the AI platform will be able to straight detect and report the correct results. On the contrary, when the system asks for the drawing to be uploaded again in an image format, this means that the PDF file and/or its contained drawing are characterized by some clear criticalities, which will not necessarily lead to some actual mistakes, but that will undoubtedly contribute to increase the probability that the platform will not be able to return some totally accurate results. It is no chance that the second and sixth tests, which finally detected some always correct measures, are the ones that asked for the least number of PNG formats, differently from the ones showing a higher error rate, where the system much more frequently demanded to upload the files again in an image format. The relationship between mistakes and image format requests is graphically and detailly depicted in Figure 45.

Figure 45 Relationship between mistakes and image format requests



This graph clearly shows that the relationship between errors made and PNG formats requested is basically a proportional one: even though this is an almost limited percentage with respect to the total number of analysed measurements, it is clear that, generally, if the number of the requests to send technical drawings in an image format increases, the number of the mistakes made by the AI platform tends to increase as well; this proves again that the first ones can be considered as a flag, suggesting that some potential inaccuracies may finally arise. Furthermore, by observing this data, it clearly turns out that all mistakes, except for one, were detected starting from drawing analysis in PNG format. Consequently, just making a manual cross-control, considering this format type only, would allow to detect almost all measurement errors, so that it could be easy to overcome the only issue related to AI usage in this process phase. The second and the sixth analyses were deliberately ignored, since they produced no mistakes; thus, they were not significant for this digression's purposes.

In the following, in Figures 46-48, a summary of the outcomes obtained from bottle analyses that have been overall carried out can be found. It can clearly be highlighted that, in almost 85% of the cases, AI usage for specification detection was totally reliable. Indeed, in 78 cases out of 92, the platform returned some correct results; specifically, in 63 cases out of the 78 considered ones, it could do this straight from the file in PDF format, without the need of uploading the drawing in JPEG/PNG one. Therefore, the error rate was relatively limited and acceptable, being equal to 14 cases out of 92. Moreover, considering these fourteen mistakes, just in one case the system returned an incorrect specification based on the single analysis of the PDF file; in all other situations, it had already noticed these formats' criticality and had thus asked for the PNG/JPEG format to be uploaded.



Figures 46-47 AI-based control accuracy

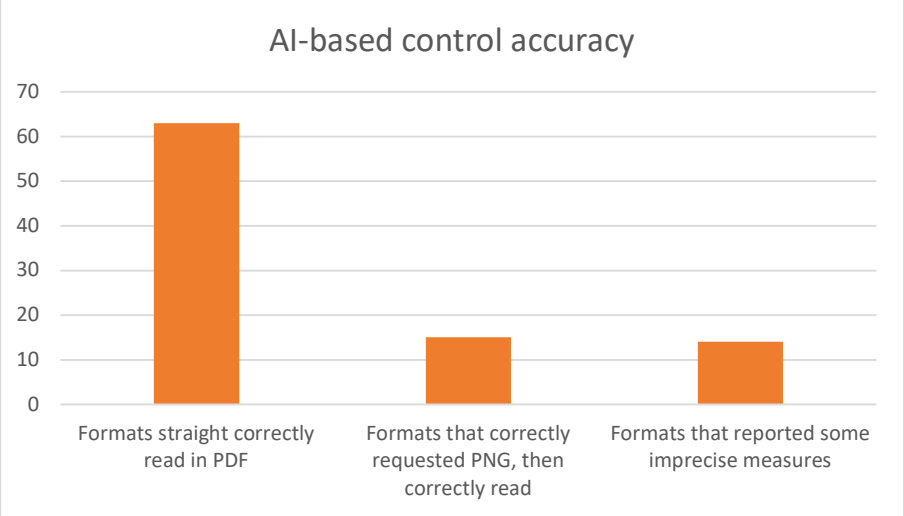
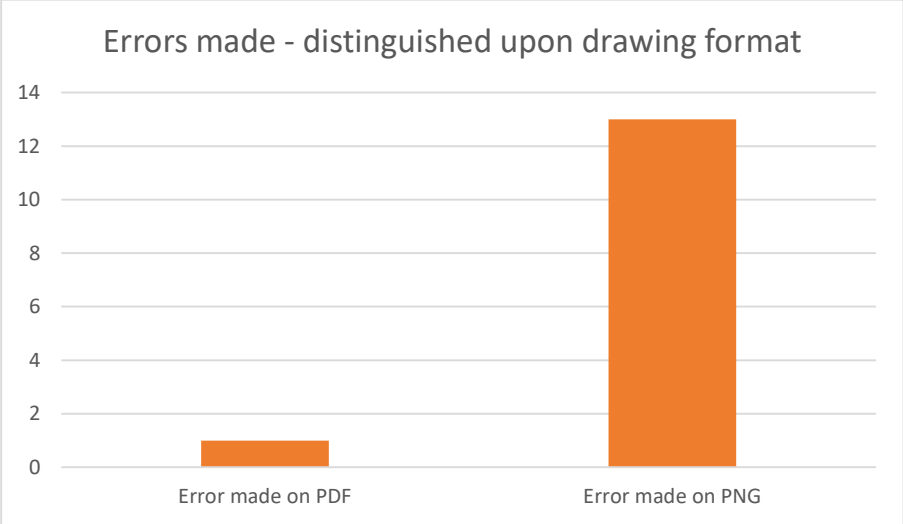


Figure 48 Error rate as a function of drawing format



After having completed all these analyses, it was then strengthened that the AI follows a reliable procedure by itself. The only exception consists in some inaccuracies, specifically due to some precise files/drawings, that can anyway be avoided at the beginning or at least minimized at the end, by just implementing the previously depicted procedures. Particularly, if customers strictly complied with the rule of sending technical drawings showing a sufficiently high definition, bottle AI-based sample controls could be appropriately carried out, without any risk of incurring into any mistakes.

5.4.3.2 CAPSULE ANALYSIS TESTS
FIRST ANALYSIS

Considering the improvement proposal concerning the analyses to be performed for order validation, AI usage has also been tested to deal with capsule dimensional controls and their subsequent change part determination. With this aim, the same AI platform *Google Gemini* was used, since its accuracy and reliability had already been largely tested during bottle controls.

At first, a test was carried out to verify AI-usage feasibility in the field of dimensional and aesthetic capsule controls. Particularly, all technical files of the formats to be analysed were uploaded, so that to provide the system with their drawings and with the specifications needed to define their features. Some examples are provided in Figure 49.

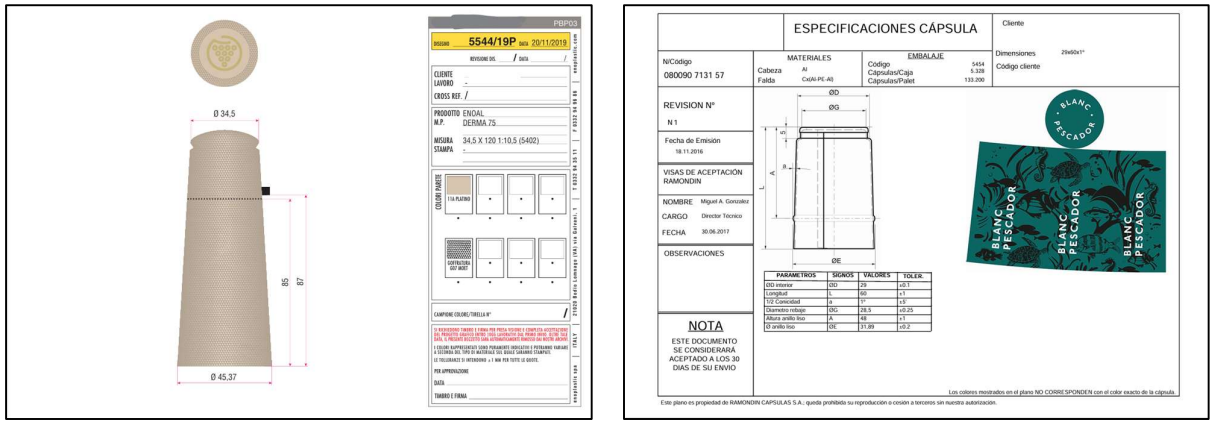
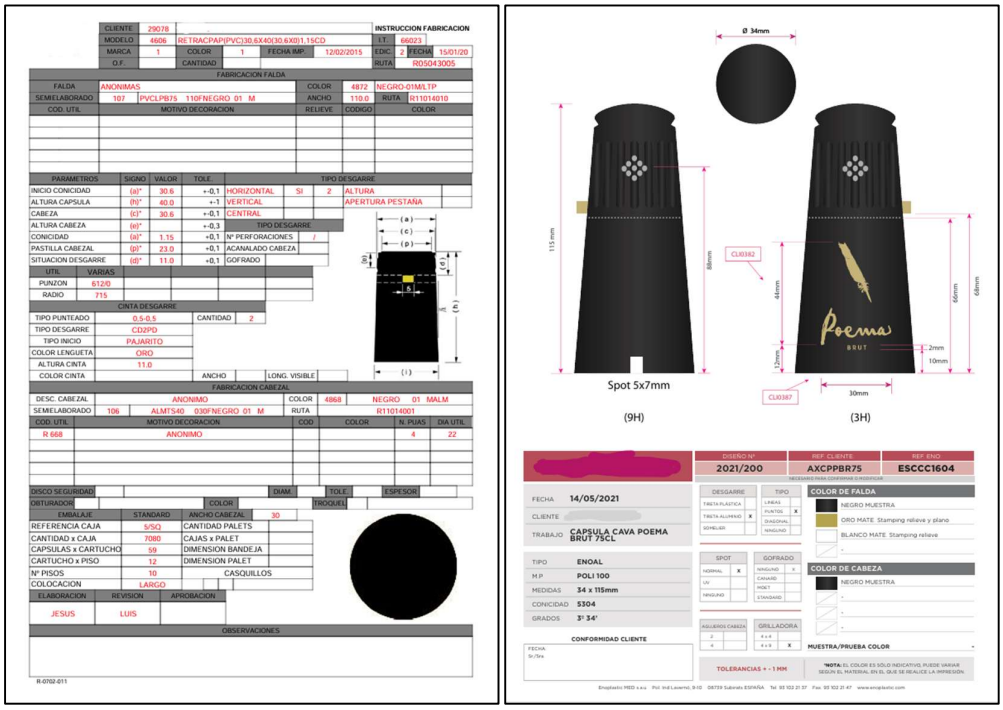


Figure 49 Example of capsule technical drawings (Robino & Galandrino)



Then, a prompt was specifically written to have the platform analyse capsule samples. This one is reported in the Appendix, in the section dedicated to paragraph 5.4.3.2.

Concerning the calculation of the base diameter, it might be necessary, because this one is not always explicitly reported among the quotas, thus it may need to be derived. In this sense, the AI platform used two different types of formulae, depending on the way capsule conicity was expressed.

In those cases where this one was reported in degrees, the following trigonometric formula was implemented:

$$D_{base} = D_{head} + 2\ x\ (length\ x \tan(conicity))$$

On the contrary, whenever conicity was expressed in millimetres, another formula was used:

$$D_{base} = D_{head} + conicity\ x\ 2$$

The results initially obtained from the first iteration of this first analysis can be found in the Appendix, in the section dedicated to paragraph 5.4.3.2, specifically in Figure 111.

By analysing them, some key criticalities emerged, which are detailly listed and described in the following lines.

Conicity tolerances: even in the cases where these ones were explicitly reported in the drawing, they were not anyway returned by the system. Therefore, it was necessary to specify in the prompt that, whenever tolerances clearly figure among drawing's data, they need to be included, specifically for each reported measure (diameters, length and conicity).

Colour assumption on a visual basis: it occurred that, whenever capsule colour was not explicitly described among its specifications, the platform assumed it on a primarily visual basis, starting from the colours of the capsule image specifically figuring in the drawing. This is a critical behaviour, because it is almost always explained that capsule image colours may not correspond to the real ones. Thus, it was specifically introduced in the prompt that the colour can never be determined on a visual

basis, but that it needs to be introduced as part of analysis' results, only if some information concerning it expressly figures in the drawing. On the contrary, if no specifications about it can be found, it is sufficient to state that no data is available to populate this field, in relation to the capsule format that is being analysed.

Spot detection: the potential presence of the optical centring needs to be reported only in case some information concerning it explicitly appears in the drawing, among the considered capsule format's specifications. Indeed, it may occur that the system detects the presence of the optical centring, simply starting from a generic sign figuring in the drawing, without any details concerning it being explicitly shown. Therefore, a clear indication relative to this aspect was added to the initial prompt: the presence/absence of the optical centring needs to be detected only if there is some data specifically concerning it; otherwise, this field is to be left empty, specifying that there is no available information with respect to this feature. Moreover, it was specified that, whenever the spot thought for optical centring is unambiguously present, but no specifications concerning its dimensions are shown, then these last ones cannot be assumed or estimated, based on some standard scenarios. This means that, in these cases, the system should only point out that the spot for the optical centring is there, without reporting any measures concerning it, so that to allow for a higher analysis clarity. In this way, spot dimensions will be introduced only if they are clearly defined among capsule specifications.

Base diameter computation: a situation occurred where capsule base diameter was incorrectly computed, because of the system using a trigonometric formula, despite the conicity being expressed in millimetres, rather than in degrees. Therefore, it was decided to further modify the initial prompt, by strengthening the importance of dealing with base diameter calculations, in such a way to implement the formula that best complies with the way conicity is expressed.

Other detected diameters: by comparing the results provided by the AI platform with the ones suggested by the manually analysed capsule formats, a new necessity arose: whenever some other diameters are included in capsule picture, being either smaller or larger than the head and base ones, it may be particularly useful to ask the system to clearly return them, so that they can be taken into account in the choice of the change part type to be paired with the considered format.

Once these issues had been approached and investigated, the initial prompt for capsule analysis was further refined and optimized, obtaining the result shown in the Appendix, in the section dedicated to paragraph 5.4.3.2.

Then, by providing this new prompt to the platform, with the aim of checking its reliability, the same capsule formats were analysed again, obtaining the results reported in the Appendix, in the section dedicated to paragraph 5.4.3.2, specifically in Figure 112.

By observing the obtained results, it can be noticed that the new prompt turned out to be highly effective, since it guaranteed an accurate and precise reading of the uploaded capsule formats, with an error rate of zero. This scenario was also undoubtedly favoured by the lower complexity and the better graphics of capsule drawings, if compared to bottle ones. This demonstrates that the AI can be optimally adopted also and above all in detecting capsule specifications, thus allowing the analyses to be speeded up, while also improving their accuracy. Indeed, capsule dimensional controls are currently carried out starting from physical samples; particularly, it often occurs that their specific quotas are not even measured, since operators just visually compare different formats, by overlapping capsules, in such a way to liken their dimensions. Thus, the AI usage, whose implementation necessarily requires sample technical drawings, could directly and specifically improve the way in

which controls are currently thought and organized, so that to always detect some precise, accurate and univocal measures.

With the aim of getting the most out of the adoption of this new control procedure, after having proven its practical applicability in the phase entitled to capsule dimensional verification, some other tests were performed to implement it also in relation to the choice of the capsule change parts to be paired with the different formats. Similarly to what has already been explained for bottle analyses, the AI platform was asked to automatically generate a table, containing all data obtained for the processed formats. Then, by using this one as an input, together with sample verification procedure, the system was also requested to determine the number and type of necessary capsule change parts.

The prompt that was specified for this new application can be found in the Appendix, in the section dedicated to paragraph 5.4.3.2. In the same section, specifically in Figure 113, the results of the AI-based determination of capsule change part type and number can also be found.

By analysing and comparing them with the outcomes of the controls that had previously been manually carried out by the operators, it could be concluded that, similarly to what had already happened in the case of bottle analyses, the AI platform again revealed to be very accurate in determining capsule change parts to be matched. In fact, during the order validation phase, it is not necessary to already choose the most compatible pre-worked part, nor to detailly make some special and specific evaluations. On the contrary, it is sufficient to define the number of different change parts to be used and to identify their necessary types, by simply making a general and approximated distinction. Therefore, considering this purpose, the AI turns out to be a valuable tool, reducing the time needed for these analyses and providing an adequate support for the level of detail that this phase requires.

SUBSEQUENT ANALYSIS

In order to further test the reliability and accuracy of this new procedure for capsule control management, another test was performed.

Generally, the AI continued to return some totally correct and precise results, except for one single detected criticality: sometimes, it was needed to upload a screenshot of capsule technical drawing alone, since it happened that the PDF format initially provided for the analysis contained several technical drawings referred to different capsule types. Of course, in those cases, the system could not understand by itself which was the format to be analysed. Therefore, to make sure that the analysis was carried out in an accurate way, it was required to upload the screenshots of the drawings to be processed one by one, with them being then correctly analysed.

In conclusion, AI-based capsule detection has proven to generally be reliable and correct, with an error rate being even lower than the one emerged for bottle analyses, since it basically tended to zero. Clearly, as it has already been explained when dealing with bottle samples, the general accuracy of the AI platform only depends on the files provided by the customer. If these ones contain the drawing and the specifications referred to one capsule format only and have a high-quality graphics, then the system will be perfectly able to correctly detect all data. On the contrary, if several different capsule formats figure within the same file or if drawings clearly show some major defects, that will make the analysis particularly complex even for human operators, then their intervention will clearly be necessary.

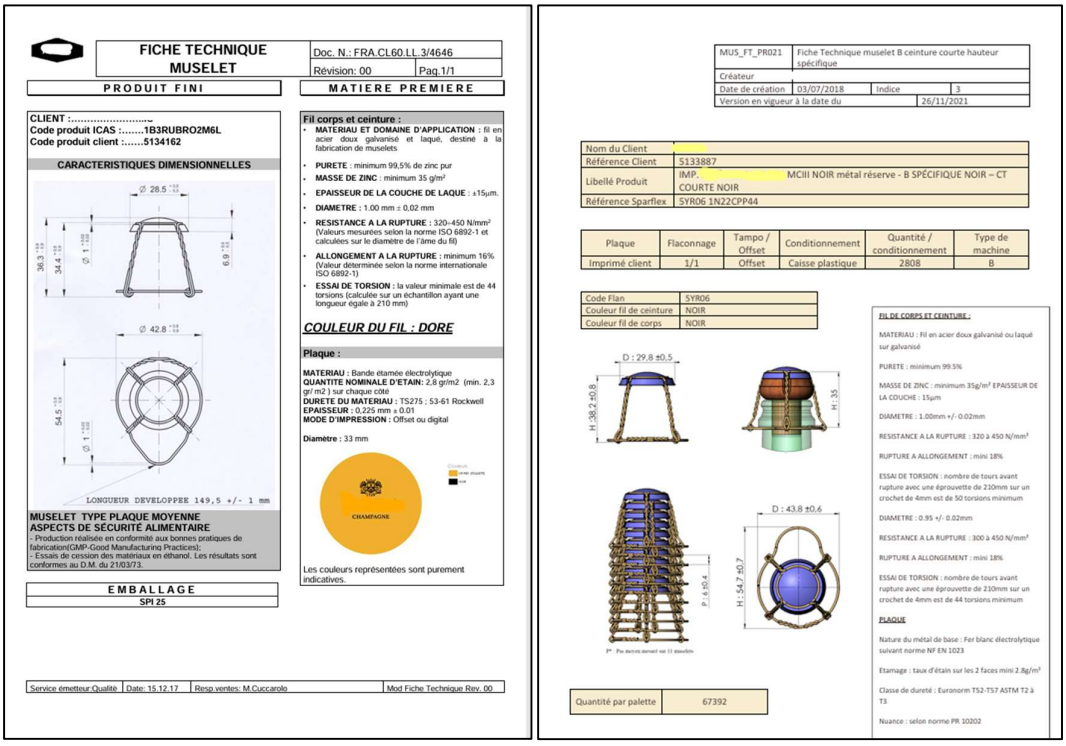
The results of this subsequent analysis are reported in the Appendix, in the section dedicated to paragraph 5.4.3.2, specifically in Figures 114-115.

5.4.3.3 WIRE-HOOD ANALYSIS TESTS
FIRST ANALYSIS

To conclude the evaluation of the improvement proposal concerning AI usage to support the analyses to be performed during the order validation phase, this previously detailly described alternative control procedure has also been tested in relation to the analyses made on wire-hoods. Specifically, the same AI software *Google Gemini* was used to deal with wire-hood dimensional verification and their subsequent change part determination.

The implemented iter was the same of the one that has already been described when dealing with bottle and capsule controls. Basically, wire-hood technical drawings (see Figure 50) were uploaded on the AI platform, asking it to analyse them, based on a specifically written prompt, which figures in the Appendix, in the section dedicated to paragraph 5.4.3.3.

Figure 50 Example of wire-hood technical drawings (Robino & Galandrino)



Then, the results returned by the AI platform were compared with the ones that had already been obtained by operators' manual measurements. In the end, they showed AI total reliability and accuracy in detecting wire-hood dimensional specifications, with a null error rate. This was surely favoured by these components' technical drawings being relatively simple, undoubtedly less complex than the ones of the other sample categories.

Specifically, the results of this first wire-hood AI-based analysis are reported in the Appendix, in the section dedicated to paragraph 5.4.3.3, in Figure 116.

Similarly to the previous cases, after having checked result accuracy and precision, the system was asked to use these outcomes to pair each wire-hood format with its most appropriate change part type.

The prompt that was specifically written to perform this other function is reported in the Appendix, in the section dedicated to paragraph 5.4.3.3.

In the same section of the Appendix, detailly in Figure 117, the results of this other control step are introduced. By focusing on them, it can be noticed that, also in this case, they confirm AI total reliability in managing this process phase, showing a null error rate.

SUBSEQUENT ANALYSIS

With the aim of definitively proving AI reliability and accuracy in handling wire-hood sample controls, some other formats were analysed, which finally confirmed the already highlighted positive trend. These outcomes can be specifically found in the Appendix, in the section dedicated to paragraph 5.4.3.3, in Figures 118-119.

5.4.4 CONCLUSIONS ON AI-BASED CONTROL ANALYSES

Considering the analyses that were performed dealing with bottles, capsules and wire-hoods, it can be concluded that implementing this alternative control procedure can really lead to a reduction in the time needed to accomplish order validation, while also improving analysis accuracy, because of this system showing a limited error rate, both in terms of frequency and severity. Indeed, the simple adoption of technical drawings rather than physical samples constitutes a step forward by itself, since the company would be able to base its controls on more precise and univocally defined data. This represents a first improvement scenario, which can be further strengthened and enhanced by adopting the AI to deal with technical drawing analysis, having this proposal's general reliability been largely demonstrated.

Nevertheless, with the purpose of increasingly optimizing this process, in such a way to nullify the error rate, the company was asked to evaluate the idea of buying an AI software licence, so that to operate with the premium version of these platforms. In this way, the firm could take advantage of a greater precision in the vision systems, with the aim of further reducing the error frequency. Moreover, the business may have access to a wider range of additional functionalities, in such a way to increasingly accelerate sample controls.

6. STRATEGIC IMPORTANCE OF AFTER SALES DEPARTMENT

6.1 AFTER SALES INTERVENTION IN COMMERCIAL OFFER PHASE

While analysing production process actual state, it emerged that the After Sales functional unit covers a crucial role in shaping and managing the relationships with the customer, not only in terms of assisting him after machinery delivery, but also at the commercial level. Indeed, this department is officially aimed at maintaining machines over time, including the proposal of some commercial offers, concerning the sale of new change parts to handle any potential format changes on an already installed machine. Beyond this, while detailly analysing the currently implemented selling iter and discussing it with the operators entitled to the different company's units, it was noticed that the After Sales often covers another key and determinant role, taking the full responsibility to propose and finalize the sale of new machines too.

In other words, an anomaly has come up, which characterizes the process at present: this functional unit, that is located at the end of the production process, often already intervenes at the start of it, taking on the management of a process phase that is officially entitled to Commercial Office. This means that, in some cases, the After Sales does not only follow machine's flow from the moment in which this one leaves the production site up to the end of its useful life, but it already plays a role in the initial process steps, tackling order's management straight from the definition of the related commercial offer. Indeed, in a direct meeting with the personnel employed within this department, it emerged that, in almost 80% of cases, customers order their new machinery by addressing this unit, rather than Commercial Office. Clearly, this occurs when dealing with clients that already own some machines produced by *Robino & Galandrino*, who have developed over the years a trust-based relationship with the operators of the After Sales Department; specifically, because of this, they often think that it may be more efficient to deal with them when buying some additional equipment, given the feeling that these ones can better know and satisfy their real needs.

Therefore, Commercial Office plays a crucial and vital role in searching for new markets to target and in having the business expand, other than in managing the relationships with new potential customers, who are getting in touch with the company for the first time and therefore need some reference people to guide them in firm's reality and to support them in formalizing their first order. On the contrary, when the purchasing request for a new machine comes from customers that are already fully involved in company's world, it is the After Sales that is practically entitled to manage most of the commercial transactions.

Detailly, even though the role of the commercial employees as such is of essential importance, it is undeniable that these ones directly get in touch with the customer only in the preliminary phase of a machine's lifecycle, namely just in the gap of time relative to commercial offer definition and, occasionally, during equipment production stage. On the contrary, After Sales operators build some deeper and tougher professional and human relations with the client, since they support him from the end of product manufacturing phase up to the end of machine's useful life, for a period of approximately 15 years. Therefore, it is easy to understand that, when it comes to approach the purchase of a new machinery, the customer often feels the need of primarily consulting After Sales personnel. In fact, considering the usually required high degree of customization and the cost impact that he needs to face, he may prefer addressing this functional unit, given the deep-rooted and blunt relationship between them, thus the greater awareness that these employees have of his operational conditions and requirements.

Briefly, this detected process anomaly is intrinsic to the different nature of these two functional units and is primarily due to the human factor, since it was born and then rooted in company's routine practise as a natural evolution of the relationships between technicians and customers. Differently explained, it is physiological that a person, when buying a new product and defining its necessary specifications, is naturally inclined to rely on a counterpart that he totally trusts, because of a deeper knowledge of their respective positions.

Concerning this aspect, the perception that the company first had of this scenario needs to be investigated. Specifically, when this process peculiarity was clearly disclosed, it was depicted as an "anomaly". The choice of this word was not a random one; rather, it was accurately evaluated, since defining the just depicted situation as a "criticality" would have been inappropriate. It is not a case that it was separately addressed in this dedicated paragraph, instead of being included in section 3, concerning the emerged criticalities and the *FMECA* drafting. Indeed, the intervention of the After Sales in the vending process of a new machine is not only and necessarily a problematic aspect, but it turns out to be a more complex and multi-faceted point, which produces both advantages and disadvantages. Therefore, the word "anomaly" was thought to be the most appropriate one, since it does not solely imply some totally negative aspects, rather a complex situation, which had never been ex-ante planned and formalized.

This one exactly corresponds to the context in which the company ended up: theoretically, it had entitled Commercial Office to be the one to deal with the negotiation and sale procedure of any new machinery, whereas the After Sales "only" had to manage the requests concerning all already sold and produced machines, thus planning its commercial intervention just in terms of spare and/or change part selling. Then, the fact that this office has finally gone beyond the competence area that it had initially been assigned to represents a process anomaly, since it reveals to be an uncontrolled operation, which misses any mechanisms to be supervised and monitored in its risks. Indeed, even though this scenario undoubtedly shows some positive outcomes, which will be detailly investigated in the following, it is undeniable that it currently stands as a process flow that is not formally and directly recognized, monitored and documented by the company. Therefore, with the aim of managing it at best and avoiding that it turns out into a counterproductive boomerang effect, the necessity emerged to frame and plan it upstream, while defining firm's organizational structure.

In conclusion, the frequency at which this scenario occurs and its relevance at organization's performance level caused the necessity of more deeply analysing it, with the purpose of understanding its advantages and disadvantages in affecting the balance of company's dynamics, thus allowing to maximize the positive factors, minimize the negative ones and optimize After Sales intervention in this phase. Detailly, this process peculiarity turned out to be a non-negligible one, since the additional role that this department has autonomously taken over time, as a consequence of customers' needs and requests, was specifically due to the market positioning of the company, which operates in a segment whose dynamics are strongly determined by clients' will. Moreover, another supporting element lies in the fact that, if this anomaly were properly managed, it would provide some advantageous benefits to the firm, also allowing to solve, or at least to improve, the current criticalities. Thus, it was decided to formalize this process aspect, by proposing a possible official way to handle it, in order not to depict it as an anomaly anymore, rather as a willingly and consciously integrated element of the flow, so that to exploit its full potentialities.

6.1.1 ADVANTAGES

This analysis will start from the positive aspects connected to the After Sales managing a new machine's vending. Particularly, it needs to be straight stated that these ones are tied to the ability of

this functional department to exploit the trust that has been developed with the customer over the years at the technical level, as well as to leverage on the deep knowledge of his real needs. In the following, the main advantages are listed and characterized.

After Sales as an "antenna" of customer's needs: the After Sales Department, being at close contact with machinery's end-users, can detect their exigencies before any another functional unit. Therefore, it plays a crucial role in identifying in a useful time which are the directions alongside all most recent market requests and trends are moving. Clearly, this has a prior relevance at the strategic and commercial levels, since it allows the company to anticipate all sector's developments and evolutions and to get updated about them by time, in such a way to propose and implement some innovative solutions, to be perfectly aligned with customer's exigencies. So, if the After Sales were formally allowed to deal with commercial transactions, the just depicted aspect could be efficiently and effectively exploited and maximized, thus ensuring that the company constantly keeps up with the most recent trajectories of the market segment where it operates.

Technical credibility and authority: given the better knowledge and trust which characterize the relationship between the customer and the After Sales employees, that has already detailly been depicted in the introduction to this section, the first perceives the second as technically experienced counsellors, not only as sellers. Thus, by leveraging on this feeling and by exploiting its deep insight of the limits of the machines that the customer already owns, the After Sales unit can offer a new machinery as a real solution to existing problems and difficulties. This undoubtedly represents an optimization of the sale phase, which can in this way be speeded up and made more efficient, also producing an increase in customer's satisfaction. Indeed, he will perceive the commercial offer as an actual instrument to overcome existing production barriers; therefore, he will be more inclined to accept it and, being this one perfectly tailored to address his real needs, he will be fully satisfied with it, thus producing some clearly positive outcomes at the reputational level. Moreover, if this scenario occurs, the people selling the machine will be the same as the ones who will then cope with its installation and maintenance; thus, they will straight have an increased willingness of its technical limitations, then avoiding those possible consequently arising problems, due to an initial "over-promising" approach.

Selling iter speeding up: as it has already been introduced in the first lines of the previous point, it is possible to take a great advantage from the After Sales Department being fully involved in customer's productive matters. In fact, thanks to this, this unit is able to immediately recognize when one of his machines has reached the end of its useful life, when it is not anymore sufficient to satisfy his exigencies (in terms of production speed) or when the costs to face any necessary repairs and/or to bear the adaptation of some new sample formats exceed the marginal value of the machine itself. Briefly, this functional unit is perfectly able to detect by time any customer's exigencies, so that to offer a new equipment in the exact moment he really shows this need and to activate, by doing so, a direct selling channel, which allows to significantly speed up this phase.

Increased reliability and precision in offer definition: with the aim of highlighting the relevance of this aspect, it is needed to recall that one of the major criticalities, that has been identified at change part process current state, lies in the non-compatibility between sold machinery's specifications and customer's samples to be worked on it. This one is due to Commercial Office's too superficial knowledge of the limitations to be evaluated in the offer phase. Considering this, After Sales intervention in proposing a new machine turns out to be particularly valuable. Indeed, this department is perfectly aware of the types of change parts, settings and options that customer's productive reality needs. Therefore, it can submit a proposal that precisely and exhaustively includes all necessary

specifications to integrate the new machine within customer's machine pool. This guarantees that this one will be accurately adapted to his productive exigencies, in turn reducing the configuration error in the offer phase, so that to avoid any subsequent problems concerning any non-compatible or missing components. In this way, the idea of exploiting this department's commercial role, together with its technical competences and abilities, also allows to address and reduce the occurrence probability of one of the main criticalities emerged when defining the *FMECA* table.

6.1.2 RISKS

Despite the numerous positive elements that have been previously exposed, it is undeniable that After Sales intervention in trading new machines however also produces some structural and financial risks, which are primarily due to the fact that this scenario has spontaneously emerged, without being planned and framed ex-ante in the context of company's dynamics. In the following, the major disadvantages are listed and detailly analysed.

Conflicts and internal rivalries, demotivation, confusion: since After Sales intervention in the commercial area had not been planned ex-ante, it may occur that it is interpreted as a sort of a "takeover" from this functional unit, which goes beyond its competence field, invading the job area specifically entitled to Commercial Office. This organizational anomaly may lead to the birth of some tensions and of a certain lack of clarity relative to the allocation of company's roles and information, thus increasing the frustration of those employees working in overlapped areas and reducing the general cooperation internal to the company. Moreover, whenever the After Sales is the only department to entirely deal with machine's sale, without being anyway assisted by Commercial Office, this might also cause a feeling of confusion and disorientation in the customer himself, who, despite having personally requested After Sales' technical support and aid, still however deems necessary to discuss with commercial employees, since these ones are considered to be more competent when it comes to legal and contractual aspects.

Reduced negotiation abilities: the personnel entitled to the after sales assistance is undoubtedly specialized in managing all technical problems, which are encountered by the customer during machine's use phase, thus in quickly and accurately satisfying all his requests and needs. Then, since in its routine professional activities it adopts a more technical and engineering-based approach, it is highly probable that this functional unit does not have those negotiation competences that are necessary to manage an entire sale process. Consequently, it may occur that, when it intervenes in this phase, it allows for some excessive price discounts, also because of the more confidential relationship that these employees have with the customer. This might lead to ignore product's profit margin in favour of service quality, ultimately reducing sale's profitability.

Reduced legal and contractual knowledge: referring again to what has already been explained in the previous point, it is also possible that the After Sales does not entirely and deeply possess the necessary set of legal and contractual competences and notions, in relation to which commercial employees have on the contrary developed a stronger understanding. This causes the possibility that After Sales personnel is not fully aware of all updated procedures to manage contractual documents and conformity declarations, thus making some major mistakes or missing some relevant aspects in defining the contractual clauses or in preparing machine's safety certifications.

Operational overload: despite the intervention of the After Sales Department in the selling process can reveal to be precious and, once awareness about it has been acquired, almost unmissable, it is undeniable that the management of this additional task requires a degree of attention and care that often causes an overload of the roles played by this functional unit. Indeed, this scenario makes it

face a considerable complexity in dealing with time management, maybe favouring a sale negotiation with a customer, instead of handling a machine breakdown with another one. To sum up, this criticality lies in the fact that, since this unit needs to deal with too many aspects, it may find itself to be overwhelmed, causing a decline in assistance service quality, thus damaging company's reputation in this sense. From this, the necessity arose to formally plan this additional After Sales activity as an integral part of its job description, in such a way to guarantee an optimal and efficient allocation of human resources in this field.

Loss of strategic data: the company does not currently have any CRM (Customer Relationship Management) software. Consequently, when the offer and the potential resulting sale are entitled to Commercial Office, all related documents are saved in the dedicated file internal to this department, that has already been mentioned in paragraph 3.2. On the contrary, when the machine is offered and sold by the After Sales, all data relative to it is saved by this other functional unit. Therefore, because of this misalignment in storing the information into separate documents, it is not possible to get a general and shared view of all aspects concerning past sales; this results in incomplete data to base market analyses, future offers and financial planning. Indeed, if the information is saved in a paper version or in disjoined files, which are only stored on the PC of the employees, it may occur that some useful details are lost, that the necessary actions are not straight carried out and that reasonings and actions are based on non-updated data and/or on wrong hypotheses.

6.1.3 PROS AND CONS BALANCE

Considering the just exposed pros and cons, relative to After Sales intervention in dealing with the commercial vending of new machines, it has become evident that the solution to this process anomaly is not the one of prohibiting this functional unit to handle the selling phase, rather that of transforming this role, that has spontaneously emerged, into a codified process, to be planned ex-ante. In fact, since the After Sales has autonomously taken this additional task, in such a way to meet a clear exigency shown by the customer, it is unconceivable that the company reacts by ignoring this need and bypassing this process anomaly. Furthermore, the relevance of the positive aspects that can be generated for the whole production flow further strengthens the necessity of officially framing and planning this scenario. In the following, the proposal will then be described to define an official and conscious procedure to deal with this aspect, by specifically organizing it in its key features and considering that this one is based on a plate of collaboration and cooperation, that is required from both Commercial Office and After Sales.

Clear definition of role allocation in the selling field: with the aim of better defining and framing who needs to intervene at the selling level and when, it was thought to propose a clear competence distinction. Considering what has been exposed in the introduction to this chapter, offer management for new machines destined to new customers is only handled by Commercial Office. Then, the improving action is to be found in the sale of new machines to already existing customers: if these ones sent their request straight to the Assistance Department, this one would officially and formally be allowed to personally cope with the negotiation process, under condition that this unit would still be constantly supervised by Commercial Office. Specifically, the management of any commercial offer's phases would formally be divided between After Sales and Commercial Office, by allocating to each one the performance of the activities where it can generate the highest added value. Briefly, this first proposal consists in making sure that Commercial Office always covers a monitoring and coordination role for any commercial offer, figuring as the functional unit entitled with the responsibility of this phase, but simultaneously contemplating that, in those cases where the customer

explicitly asks for After Sales support, this one can directly intervene and play its role, from an operational and mainly technical perspective.

Formalization of a standardized procedure for After Sales intervention: with the aim of formalizing the management of the situations in which it is the After Sales that deals with the commercial offer of new machines, it was also thought to ex-ante plan and define a standardized procedure, that can regulate its ways to intervene, so that to optimize the cooperation between After Sales and Commercial Office and ensure that the process is always precisely controlled. Thus, this flow would be activated, if it were the After Sales to perceive the necessity to sell a new machinery, because of these employees explicitly receiving a request from the customer or because of them personally detecting the inadequacy of the current machine pool, with respect to client's productive dynamics, that they closely and extensively know. If this scenario occurred, the subsequent process would be articulated into these main phases:

- Offer preparation: the After Sales prepares the offer for the new machine, paying particular attention to its technical configuration and asking Mechanical Technical Office for any necessary clarifications;
- Offer validation by Commercial Office: commercial employees define the contractual and legal aspects, the sale margin and the payment terms;
- Offer proposal: the offer, having officially been validated by Commercial Office, is proposed to the customer by the After Sales;
- Offer acceptance: Commercial Office takes on the phases relative to offer closing, sale contract official signature and consequent order definition.

It needs to be noticed that this constant coordination between After Sales and Commercial Office personnel may also favour competence and knowledge transfer. Indeed, the first one could acquire better awareness of the negotiation techniques and of the management of the contractual and legal aspects, whereas the second one would be able to enrich and strengthen its knowledge at the technical level, by better understanding which are machines' real limitations. Among all, this could allow to reduce the criticality connected to the non-compatibility between the proposed configuration and the products to get worked, that emerged when preparing the *FMECA*. Indeed, with Commercial Office acquiring an increased awareness of the technical specifications to comply with, these ones could better be considered when dealing with commercial offer definition and proposal, in such a way to minimize the problematic outcomes that necessarily derive from its superficial definition. Moreover, this competence flow would not only naturally and spontaneously enrich human resource management, but it would also be perfectly inserted in the development roadmap along which the company is already moving, according to the logics of Industry 5.0. This would strengthen and corroborate some already launched projects, which are specifically dedicated to train cross-sectional personnel, being increasingly involved and taking on greater responsibility in making its contribution to company's dynamics (*R. Stark, G. Seliger & J. Bonvoisin, 2017)*.

Definition of company's figures specifically entitled to this role: considering that, as it has already been previously exposed, the management of this additional task may result in the After Sales being overwhelmed, a further proposal to optimize this aspect management lies in defining and introducing some company's roles, to be specifically entitled to cover this function. Particularly, the idea would be the one of formally introducing some additional hybrid figures in firm's organizational chart, so that to allocate some resources belonging to the After Sales Department to the vending of new machines, by also contextually favouring the cooperation and collaboration with Commercial Office. Therefore, these professional figures would hierarchically be framed within the After Sales unit,

because of their technical competence, but they would also simultaneously and functionally belong to Commercial Office, concerning the optimal management of the negotiation and contractual aspects. These workers would then contribute to formally adopt a *LIS* (Lean and Integrated System) approach within the company, since they would lead to the birth of some cross-functional teams of people, having different functional expertise and working co-ordinately together towards a common goal, thus cutting across the structure and facilitating collaboration and interaction between divisions/functions *(Francesco Franceschini, 2001).*

CRM software adoption: with the aim of tracking any commercial transactions and always ensuring a complete and overall visualization of the current state of the relationships with the customer, the firm was also proposed to buy a CRM software. Indeed, by adopting this system, the company could have the chance to exploit a shared platform, in such a way to centralize the information concerning actual and potential customers, including the commercial offers and the sale contracts that come out of them. By doing so, the data relative to all transactions (both the ones being entitled to the After Sales and the ones being managed by Commercial Office) could be acquired, stored, elaborated and analysed in a single location. This information would be accessible from whoever needs to consult it at any time, in such a way to guarantee the availability of all necessary data for future and current exigencies. Indeed, CRM platforms were first actually introduced with the purpose of improving the management of the relations with the customer, so that to simplify the processes, enlighten the administrative burdens and improve the profitability. Specifically, to reach this purpose, these systems support and put in contact the different functional areas and allow them to operate in a quicker and more efficient way, when they deal with both actual and potential customer portfolio. This guarantees more immediate information sharing and more efficient communication, thus favouring interactions and collaboration, which in turn simplifies the daily work and ultimately allows to closely and better manage the relationships with the customer through the entire lifecycle. Synthetically, all these aspects can be concretised by exploiting some of the functionalities allowed by CRM platforms; in this sense, these ones can be used to generate sales emails, formulate marketing campaigns, guide customer service interactions and create engaging commerce experiences, so that to help companies more deeply understanding customer's needs, thus providing him with some customised experiences to solve his problems *(Salesforce).*

6.1.4 RACI MATRIX

Considering commercial offer's management phase as a small project finalized at the generation of the order as such, it has been extensively analysed that, whenever selling some new machines to already existing customers, it is possible to take a great advantage from the joined and coordinated action of both Commercial Office and After Sales. The intervention of both these functional units allows to optimize this preliminary phase, since they are asked to play a role in the process steps where each of them reveals to have better competence and experience.

With the aim of facilitating the visualization and understanding of this task allocation, it has been decided to prepare a *RACI* matrix, to be specifically dedicated to commercial offer phase, so that to schematize in a clear and structured way how and when these involved departments are required to intervene. Indeed, this instrument consists of a table to assign all key responsibilities, so that to help clarifying how to deal with the formalization of communication and work flows and guarantee that all activities are closely updated and monitored. Basically, the *RACI* matrix ensures that each element within a project is assigned to the most appropriate resource, in such a way to clarify what is expected from each involved function. Thus, it stands as a simple but essential instrument, which helps defining roles and responsibilities to ultimately promote collaboration *(QRP, 2024).*

RACI is the acronym of Responsible, Accountable, Consulted, Informed. This distinction helps understanding how the various responsibilities are intended and allocated. Specifically *(QRP, 2024)*:

- Responsible: the resources that are directly entitled with the performance of the task, who officially perform the necessary work to accomplish it;
- Accountable: the resource within the team that is officially responsible for task's successful outcome, thus the reference person, being specific and unique for each task, that carries the burdens of correctly and fully completing the work;
- Consulted: people who are not involved in the task and do not directly contribute to its execution but are anyway consulted to provide an input;
- Informed: people who are not directly involved in the performance of the task but are anyway updated and informed of its evolution and progress.

The *RACI* matrix for the context that is being analysed is reported in the Appendix, in the section dedicated to paragraph 6.1.4, in Figure 120. In order to analyse and better understand it, it needs to be first stated that the After Sales Department was assumed to be the one entitled to bear the upstart of the vending process of a new machine. Particularly, two scenarios were considered. In the first case, the personnel in charge of long-term assistance and maintenance notices that customer's production is inefficiently managed through the current machine pool; therefore, it activates the procedure to propose a commercial offer for a new machinery, by informing the selling personnel (both the one internal to the After Sales and the one employed in Commercial Office) and the customer. In the second scenario, it is the customer before all that sends a purchasing request to After Sales selling personnel, who in turn informs the other department members.

Moreover, it is fundamental to specify that the tasks were shared in such a way to optimize this phase management, by minimizing the risks connected to After Sales intervention and contextually maximizing the positive contributions. Thus, the After Sales was assigned the management of the technical aspects relative to machine's configuration; this choice was the result of its deeper knowledge and awareness of customer's needs, which is confirmed by the practise that this one has to first address this functional unit, when needing to identify the most appropriate specifications to satisfy his productive constraints and exigencies. On the contrary, Commercial Office was provided with the management of the contractual and legal aspects and with the selling price choice, given its better knowledge and experience in this field and its natural inclination to better consider the profit margin component.

Furthermore, the ending phase of this process step was also shared between these two functional units, with the After Sales that takes on the responsibility to propose the finalized and refined offer to the customer, because of its already emerged better efficiency in persuading him to go on with the actual purchase. On the other hand, the very last step of contract signature and order issuance was assigned to Commercial Office, again considering its broader competences in this area.

To conclude, the exigency needs to be noticed to constantly inform the different functional units that are interested in the evolutions and in the updates of the commercial offer process. This necessity, which is accurately described in the *RACI* matrix, strengthens and further values the proposal to introduce a CRM software, since this one can optimally support and simplify this aspect management.

6.2 AFTER SALES IMPACT ON OVERALL COMPANY'S PERFORMANCE

In the previous paragraph, an analysis was conducted concerning the commercial role that the After Sales can play in terms of new machine offer, with the aim of explaining how this intervention can

support and encourage company's sales. However, beyond this aspect, a generalized ability is noticed for this department to positively affect sales volumes, also when considering the performance of its other tasks. In other words, other than the positive impact, in terms of profits, that this unit generates through the sale of new machinery, it is clear that the After Sales also and mainly covers a relevant role when it comes to the activities it is specifically intended for, namely the sale of spare parts and new change parts for format changes.

Therefore, to conclude this digression relative to the strategic role of the After Sales, the impact can be assessed for this functional unit to affect overall company's sales and profits. This need emerged from the progressive awareness, occurred during the analysis of change part management process, that a fundamental role in this sense is played by the Assistance Department itself, which deals with the marketing of numerous change parts. This scenario occurs because of customer's frequent need to adapt some new formats to a machine that he already owns, which is in turn surely favoured by the most recent market expectations, since this one continuously demands for new and increasingly captivating packaging.

Detailly, it emerged that 1/3 of company's profits is basically earned thanks to the activities performed by the After Sales. Particularly, within this department, the core business is represented by change parts, which constitute 70% of its total revenues. As it has already been introduced in paragraph 3.5, such a significant impact for the After Sales in terms of profits is due to the margin that this unit can apply to the sale of spare parts and, above all, to that of change parts, which reveals to be much higher than the one collected from the vending of a new machine. This occurs because, when the company deals with the selling process of a new machinery, commercial employees need to attract the customer and overcome competitors, even though these are few in the market sector where *Robino & Galandrino* operates. On the contrary, the After Sales is favoured by the fact that the customer cannot find any other suppliers that can guarantee the same level of quality, competence and knowledge of his productive peculiarities. This aspect makes his demand more inelastic, meaning that he is willing to pay an overprice, if this one allows for that conformity, compatibility and excellence that only the original producer can guarantee. This situation is even intensified by the fact that he needs to face some impending productive constraints, that further reduce his price sensitivity, which is rather replaced by the absolute priority to have the required components immediately available (*Besanko & Braeutigam, 2011)*. Consequently, the total profit earned by the combination of change and spare part sales can be significantly higher than the one initially collected from machine trading. Moreover, to further support customer's demand inelasticity, it can be stated that, if compared to the unit entitled to the sale of newly produced goods, this company's sector turns out to be more resilient when incurring into some periods characterized by a severe economic crisis. Thus, this department reveals to be a stable revenue source, being less subject to market fluctuations.

Finally, it is undeniable that, other than increasing company's profitability, the choice of optimizing After Sales service also allows to improve customer retention and satisfaction, finally strengthening the long-term relationships with them. In fact, thanks to the prompt support and to the efficient and effective management on company's side, consumers will feel valued; thus, they will increase their overall satisfaction and perceive the firm as a reliable partner, distinguishing it from its competitors and ultimately ensuring it a kind of competitive advantage and growth, being sustainable in the long run. In other words, such an efficient service helps building brand loyalty and trust, because satisfied customers are more likely to remain loyal to the company and make some other purchases in the future. Moreover, in competitive markets, After Sales service can be a key differentiator, since companies that struggle in supporting customers can gain a competitive advantage over firms that are perceived to leave them alone after having purchased a product. Ultimately, investing in a solid After

Sales service will encourage some positive word-of-mouth, thus consolidating brand image *(Jens Ackerman, 2026).*

Therefore, the impact that the After Sales has in relation to company's overall profits and, mainly, the awareness that these last ones are largely due to change part sale definitively led to the emergence of a dual need. On one side, the organization requires to better formalize, structure and streamline change part management process itself; this aspect has already been considered and practically approached by company's proposal to specifically dedicate this thesis to this precise topic. On the other hand, having not only perceived change part relevance in firm's selling panorama, but also that their management is primarily carried out by the After Sales, specifically representing its core business, the priority emerged to undertake some improvement actions in this direction too. These ones would be aimed at improving and making this functional unit more efficient, being this the heart of one of the key aspects in firm's business model, other than the plate of all other advantages and income sources that have been previously mentioned.

To more extensively and specifically eviscerate this concept, it needs to be straight specified that the company does not show any intention to reduce its own production model to the manufacturing and vending of change and spare parts only, thus minimizing the contribution of new machines to its overall sales. This choice is due to the fact that just targeting after sales services produces an excessive focus on already existing customers. Consequently, this approach would limit the exploration of new market opportunities and then business expansion, with some subsequent highly damaging effects on firm's competitivity in the long run. Nevertheless, having noticed the undoubtedly central role that the Assistance plays at the overall company's performance level, it is necessary to place it as a prior improvement target. Indeed, it is undeniable that the after sales service and the vending of spare parts and additional components do not only represent some sale complements, rather proper and real engines for firm's growth and development.

The organization has already partially recognized the relevance of the After Sales, mainly because of the characteristics of the market segment where it operates, in which it is the customer to dictate the rhythms at which the firm needs to answer his exigencies. In paragraph 2.3, it has already been underlined that company's choice to internally retain all critical technologies and processes is primarily related to the exigency of quickly responding to customer's requests, which also and mainly concern format changes; if it failed to do so, it would run the risk of him addressing its direct competitors, among which there are some realities that were specifically born to face change part offer.

Concerning this aspect, another solution that the company has adopted to administer this need at best lies in production planning and management methodology. Indeed, once production times and sequences have been established, according to which the various orders' components need to be processed, some time-buffers are straight properly inserted, in such a way to usefully support After Sales' demand. This decision was encouraged by the fact that, when this department receives some requests, these ones are usually characterized by a relevant urgency, which is due to the customer promptly needing some spare parts or, specifically for the case being here analysed, some change parts to cope with a format change. In fact, if these components were not delivered by time, he would undoubtedly encounter some production downtimes, causing some relevant reputational losses for the firm. From here, the decision emerged to always prioritize After Sales' needs when scheduling production flows, thus planning the processing of ordinary orders largely in advance. By doing so, these last ones can be accompanied by some sufficiently extended time-buffers to make them non-critical and allow them to be flexibly postponed, so that to prioritize any emergences from the After

Sales, which undoubtedly represent some critical tasks. In this way, a dual objective can be reached to satisfy the impending exigencies connected to part and format changes, by still also maintaining the certainty to deliver new machines within the pre-defined timeframe.

To conclude the analysis concerning this company's section, a particular attention can be given to the improvement actions that the After Sales still requires. Detailly, when investigating process actual state, it emerged that all main detected criticalities characterize both new machine production and after sales activities. Concerning this aspect, as it has already been explained in section 4.1.5, one of the most important problems lies in the absence of a record of the requests handled in the past. Specifically, similarly to what happens in the case of new machines, also when dealing with new format requests, a misalignment is detected in storing data, being such that, considering a period of time between the end of 1980s and 2020, a digital version of order record is missing, since this one only figures in its paper-based one.

Considering this criticality, with the purpose of definitively freeing itself from past inefficiencies, in such a way to optimize and simplify the storage and sharing of all useful information for any future orders, it is reasonable to recall the importance for the company of buying and practically adopting a CRM software. This proposal was strengthened by the increasingly frequent need for the customer to be supported by some After Sales assistants being always updated in relation to the chronological history and evolution of his past purchases and problems. In this sense, this system could allow to upload the data concerning each specific order on a single and centralized platform accessible by anyone, thus automatically storing the information of what has already been sold and using it as a starting point for any future requests, in such a way to always have access to its updated state *(Amanda McGrath, Amanda Downie)*.

Particularly, a CRM software has four main functions that can help assisting customers at best *(Amanda McGrath, Amanda Downie)*:

- Analytical: it is destined to data processing and analysis, after having collected it from the interactions with the customers, so that to understand their preferences, behaviours and buying patterns. Therefore, sales personnel can use this function to tailor marketing campaigns, forecast future sales, identify sales trends, the kinds of products and services being most in-demand and the deals that the firm is most likely to close;
- Collaborative: it is focused on facilitating communication, coordination and information sharing among the various departments and teams, as well as among external stakeholders, including distributors, partners and suppliers. Thus, this function ensures a shared approach to optimally serve customers at every step of the process, by providing a unified and complete view of their needs, that can allow to deliver a consistent customer experience, which in turn builds some stronger relationships with them. In conclusion, this turns out to be beneficial for employees, who always get a clue of the latest information, as well as for clients, who benefit from informed company's representatives;
- Strategic: it focuses on long-term customer relationships, specifically offering some analytic tools that provide insights into customer behaviour, sales trends and overall business performance. With this approach, the obtained data, that can be made even more visible and actionable by AI capabilities, will finally help businesses delivering personalised customer experiences to enhance some lasting relationships. Indeed, beyond the immediate financial gain, this function makes companies stay competitive, adapt to changing market conditions and build a more resilient business;

- Operational: it focuses on streamlining those day-to-day tasks that involve some direct interactions with the customers, so that to optimally manage the relations with them, by automating marketing, sales and service operations. Specifically, it is aimed at collecting all necessary data to show sales history and order status in a single customized dashboard, in such a way to properly sell to the customer the component that he really needs. In this way, this function allows to generate and segment marketing campaigns and to save time; for example, companies will be able to autonomously generate some tailored sales options, which are based on customer data, for instance by using some personalised messages and solutions to meet their specific wants.

In conclusion, it can be stated that the main improvement proposals to optimize the After Sales Department are aimed at making this functional unit more efficient, thus contributing to retain the customer in the long-term. Specifically, they lie in this unit cooperating with Commercial Office to exploit its full commercial potentialities and in having this department be able to track the history of the evolutions of its relations with the customer. These needs can be attained by making sure that any commercial requests are addressed through the means of a CRM software. Indeed, by keeping track of all previous offers and orders and by providing a constant and real-time update of all information, a CRM system allows After Sales and commercial assistants to always perfectly monitor customer's history, negotiation advancement and bottleneck identification, so that to offer him the best product. To be precise, the CRM software can do even more, not only clearly showing the history of the peculiarities that have characterized the relations with the customer up to the current state but also providing the personnel with some indications and advice concerning some new solutions he might be interested in, in such a way to make sure that no opportunities are missed. These ones are based on the most recent market trends, so that to identify some possible current deficiencies and improve the future offers. Therefore, the adoption of a CRM software allows for better data visibility and scalability, thus exploiting automation to keep processes efficient and manageable while companies grow up. Moreover, automation also allows to speed up all repetitive activities to save time, guarantees a quick access to all information concerning any previous interactions and simplifies some complex multi-user processes in simple workflows, so that team members can simultaneously handle several tasks, without feeling overwhelmed, thus generating higher productivity. This can ultimately improve service quality and precisely meet customer's expectations, since this one will have access to a prompt and customized communication, which will in turn favour his satisfaction, loyalty and retention, finally incentivizing him to continuously rely on the company for future purchases too *(Amanda McGrath, Amanda Downie).*

7. FINAL CONCLUSIONS

To conclude this thesis, this final section is aimed at proposing a balance of what has already been achieved during my internship experience and what, on the contrary, has been left to the company for future activities.

Starting from the achieved objectives, it first needs to be stated that one of the major advantages reached thanks to the activity carried out during my internship lies in company's increased consciousness of change part process actual state. Indeed, when this experience got started, this one was performed by following some routine practises and procedures, that had been first established and had then spontaneously eradicated because of decades of work, during which they had always been performed following the same routes. Therefore, officially and formally mapping the current way to handle this procedure allowed the firm to improve its awareness of how and why tasks are accomplished as such, so that to have the process be more closely and precisely controlled. Moreover, to further optimize this intervention and improve process visualization and structuring, I have personally proposed to apply some of the flow mapping instruments that I learnt to implement during my academic experience, namely flowcharts and IDEF0 diagrams. These ones let the company clearly understand and investigate the sequence according to which the various steps are performed and the sets of inputs, outputs, resources and constraints that pass into and out of each process function, so that to better understand how each of them operates and which kind of resources it consumes. Ultimately, this first action practically implied that some initially uncontrolled and ignored process aspects could finally be closely and continuously monitored and analysed.

In relation to this first advantage, another deeply connected one straight emerged from it: once the current change part process state had been detailly disclosed and eviscerated, the company was finally able to get aware of its actual limitations and weaknesses. Thus, by combining the perceptions that the personnel had of these criticalities and anomalies with the theoretical notions that I had personally acquired at the academic level to ideally optimize process flows, a shared effort was put in place from both sides to cooperate in formally listing all currently problematic process aspects. Therefore, the second important practical implication enabled by my internship activity consists in the company being now fully aware of all change part process deficiencies. These ones were even better formalized and prioritized through my proposal of applying to them the *FMECA* analysis model; this idea was positively evaluated by the company, which helped me in defining the severity and occurrence probability of all previously detected problems, in such a way for them to get actionable. In fact, not only the organization has now got a clear insight into them, but it has even been able to identify the most relevant and worrying ones, so that it has become easier for it to quickly define some key priorities in how to approach and overcome them.

Concerning the improvements that were proposed to address the current process criticalities, these all reveal to be actionable and practically implementable. In fact, they are the result of organizational and personal contributions and efforts, specifically aimed at searching for some tailored improvement actions, defined according to company's resources and capabilities. Among the already targeted measures, the official change part list figures, which was prepared to solve the problems arising because of its absence. In this sense, company's exigencies were considered, along with a personal request that I made, given the need I faced to better understand what is really included in "change part" definition.

On the contrary, some other aspects still require some work to be accomplished before becoming practically effective. First, in relation to quality and quantity controls, the suggested idea was that of

practically adopting some instruments that the company already owns, with these ones being further supported by some other technological solutions, that are allowed by Industry 4.0 and that I have personally proposed, starting from the knowledge I had acquired in some academic courses concerning production systems, then enriching it by some additional research. However, it is undeniable that some major investments are required on company's side to adopt these other control instruments; furthermore, these systems, as well as the ones that the firm has already bought at the theoretical level, need a change in working practises to be made operative and efficient. Particularly, the necessity to address the current way of accomplishing tasks and modify it represents the greatest obstacle to the implementation of these improvement proposals. Indeed, routines are important, since they can create discipline in the company and help developing and storing organizational knowledge, thus establishing coordination and reducing uncertainty and variance of behaviours within the firm. However, they lead to tremendous inertia, that, to be overcome, requires employees to abandon their traditional way to approach their job and be trained and educated to face it in an alternative and innovative way *(Grant R.M, 2021).*

This aspect is the kind of limit that needs to be considered also when approaching the other improvement proposals, namely the implementation of an engineering-to-order logic when handling capsule and wire-hood change part production and the adoption of a more efficient and innovative AI-based procedure to perform sample verification. Particularly, in this last case, even though I have personally carried out some tests to prove this alternative proposed system's reliability and accuracy, it is of no doubt that, for it to become common practise, a commitment is needed from the personnel to embrace this new practise and abandon the almost obsolete one. In this context, an effort is also required on customer's side, since AI-based platform's detection precision depends on technical drawings' resolution; this means that a null error rate in this kind of controls can only be achieved if the customer cooperates, by sending some high-quality files.

Finally, considering the case of the After Sales, I have personally recalled the knowledge I had acquired about the importance of coordination and cooperation flows to build some horizontal hierarchical structures. For this reason, to encourage communication as well as strategic and operational alignment between the different functional units when dealing with commercial tasks, I have proposed to construct a *RACI* matrix to clearly and formally define competence and role allocation, then also advancing the idea of buying a CRM software. These measures were aimed at increasingly moving company's structure towards the model of a *LIS* (Lean and Integrated System), so that to encourage collaboration and interaction between divisions and functions, reduce bureaucracy and make sure that the information flows are nor filtered neither distorted and that product development is carried out in a collaborative way with positive interactions. However, this new cultural paradigm may not be so easily accepted, thus requiring the company to invest in team building, brainstorming and flexibility *(Franceschini Fiorenzo, 2001)*.

In conclusion, with the aim of addressing the improvement proposals that have been formulated together, the company is not only required to make some financial investments, like in the case of quality/quantity control instruments and CRM software adoption, but it mainly needs to show some dynamic capabilities. This means that it must be able to evolve, by embracing some radical shifts in the technologies and in its business model. In fact, the first affect product and process technological base, while the second allow for new propositions of value creation and new rules of value capture in some different ecosystems *(Grant R.M, 2021)*. By doing so, this firm will be able to make the most out of the experience it has traditionally acquired, in such a way to continuously evolve and keep up with market needs and trends, thus adopting the kind of forward-looking spirit that has always characterized its history to exploit its full potentialities.

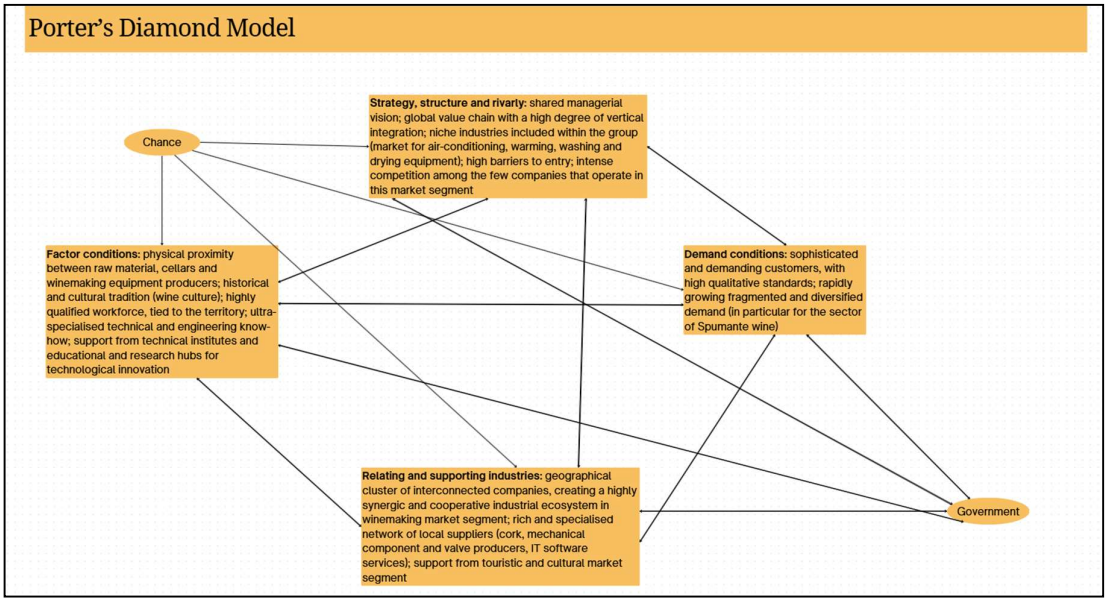
APPENDIX

2. INTRODUCTION TO THE COMPANY

2.1.3 PORTER'S DIAMOND MODEL APPLICATION

In Figure 51, *Porter's Diamond Model* adapted to Canelli's winemaking equipment market.

Figure 51 Porter's Diamond Model applied to Canelli's industrial winemaking hub

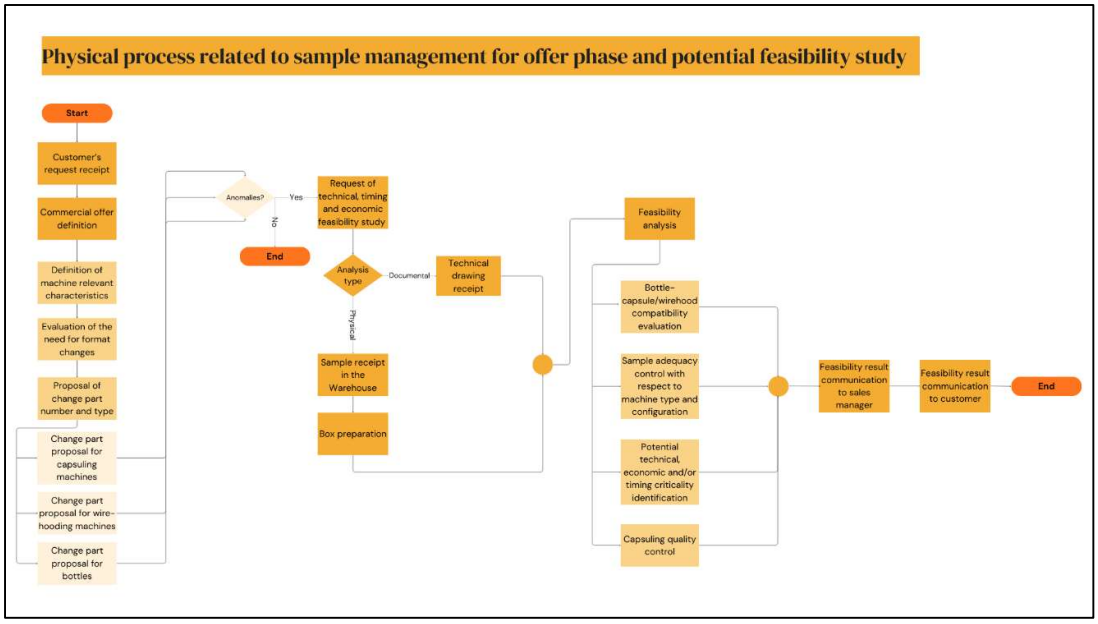


3. ACTUAL PROCESS STATE MAPPING

3.2 COMMERCIAL OFFER PHASE

In the following, in Figure 52, the flowchart related to this process phase.

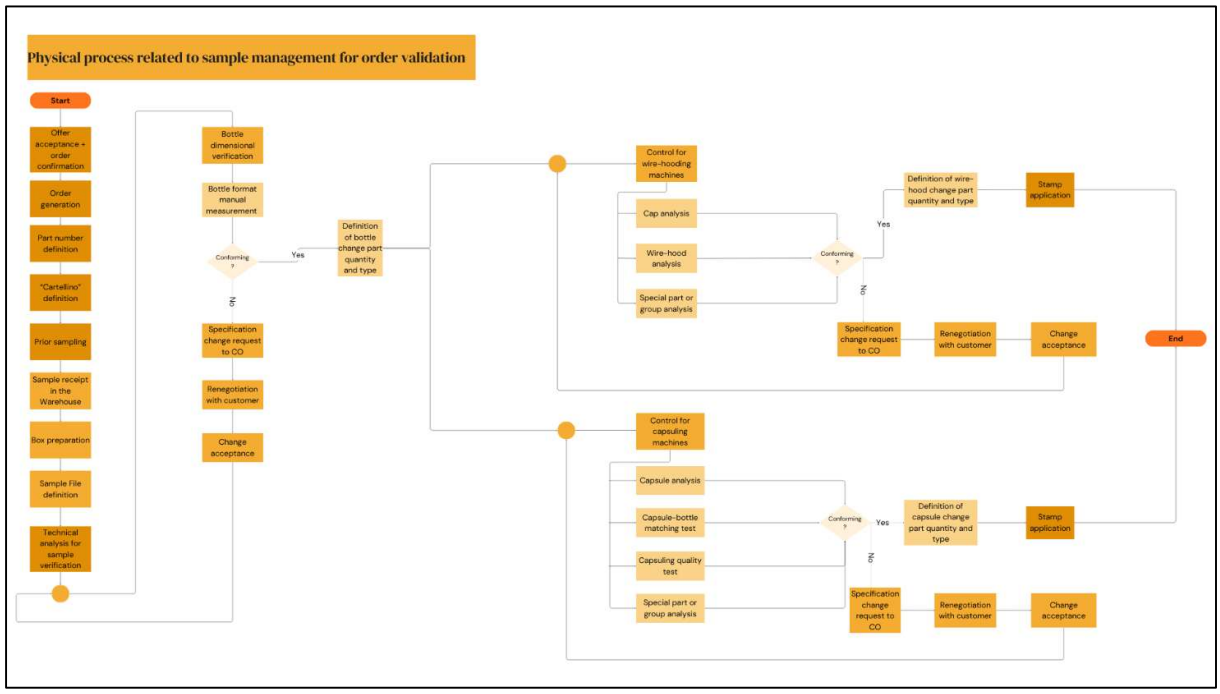
Figure 52 Commercial offer phase flowchart



3.3 ORDER PHASE

In the following, in Figure 53, the flowchart related to this process phase.

Figure 53 Order phase flowchart



3.3.3 ORDER VALIDATION PHASE – TECHNICAL ANALYSES

In the following, a detailed description of the technical analyses and controls to be performed to determine change part number and type.

Quantitative and qualitative verification of bottle change parts: to confirm change part quantity, as already explained in describing the offer phase, it is needed to measure and group bottles. Indeed, the amount of the first ones varies depending on the dimensional and geometric characteristics of the second ones, as a function of the possibility, for some of them, to be simultaneously processed on the machinery, because of the similarity in their diameters. Precisely, this scenario is affected by the compliance to some specific tolerance ranges, that contemplate it or not, depending on the speed at which the machine works. These rules are specifically reported in Table 2. Furthermore, when it comes to bottles having a screw cap, it is necessary to evaluate the need of actually processing them; if this is not required, it is asked to specify that a special group, called of "Free passage" (see Figure 54), needs to be introduced on the machine and these bottles are not considered in quantifying the necessary change parts *(Robino & Galandrino S.p.A, 2025)*.

Figure 54 "Free passage" group (Robino & Galandrino)

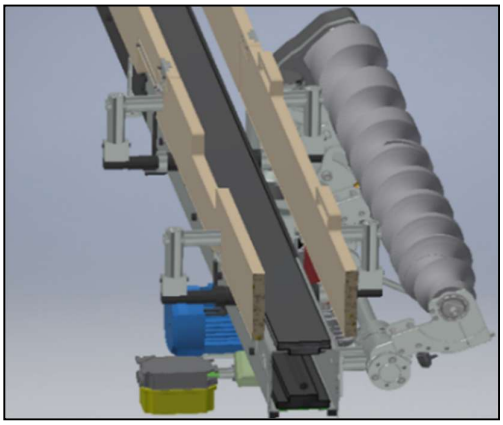


Table 2 Bottle grouping to define change part number (Robino & Galandrino)

Machine speed	**Diameter max tolerance**	**Practical rule**	**Impact on change part number**
< 18.000 bott/h	3 mm	1 change part for each 3 mm range	Less change parts
> 18.000 bott/h	2 mm	1 change part for each 2 mm range	More change parts
≥ 25.000 bott/h	0,5 mm (advised)	1 dedicated change part for each format	Maximum number

Quantitative and qualitative verification of capsule distribution bells and centring cones: first, this analysis again requires to manually measure bottle height to definitively confirm whether they can be processed on the planned machine type. Then, capsules need to be measured, particularly focusing on their length and diameter and on the ratio between the two; this will allow to detect any of them having non-standard diameters and to assess their compatibility with bottles. Also in this phase, it is necessary to group them as much as possible; indeed, change part number varies as a function of the similarity among capsules, which must be manually and visually verified, by particularly considering their diameter and length. This means that the more similar they are, the higher the probability is to be able to simultaneously handle them while processing; in fact, each single capsule group determines the construction of a corresponding distribution bell set. The indications to follow to deal with this step are specifically reported in Table 3. Total type and number of agreed sets of distribution bells and eventual centring cones is reported in the *Sample File*, also specifically pointing out which capsules have been grouped *(Robino & Galandrino S.p.A, 2025)*. Moreover, a sticky tag is attached to the package containing capsule samples, specifying machine type, order, customer's name, bell code and number, centring cone code and number (if these ones are included). Finally, technicians also fill in a specific table, which can be found in capsule technical drawing, by inserting all relevant specifications concerning them; in order to simplify the visualisation of those ones that can be worked using the same change part, the table is populated by successively writing the capsules that can be grouped.

Table 3 Capsule distribution bells as a function of diameter and length (Robino & Galandrino)

Capsule type	Diameter variation	Length variation	Distribution bell
Heat-shrinkable	Minimal	**5 mm**	With carvings
Polylaminate	Minimal	**3 mm**	Without carvings + pin
Tin	**0 mm**	**0 mm**	Without carvings
Sparkling wine	**0 mm**	**5/6 mm***	Without carvings + ring

*Only in case of lengths > 90 mm and non-reduced conicity

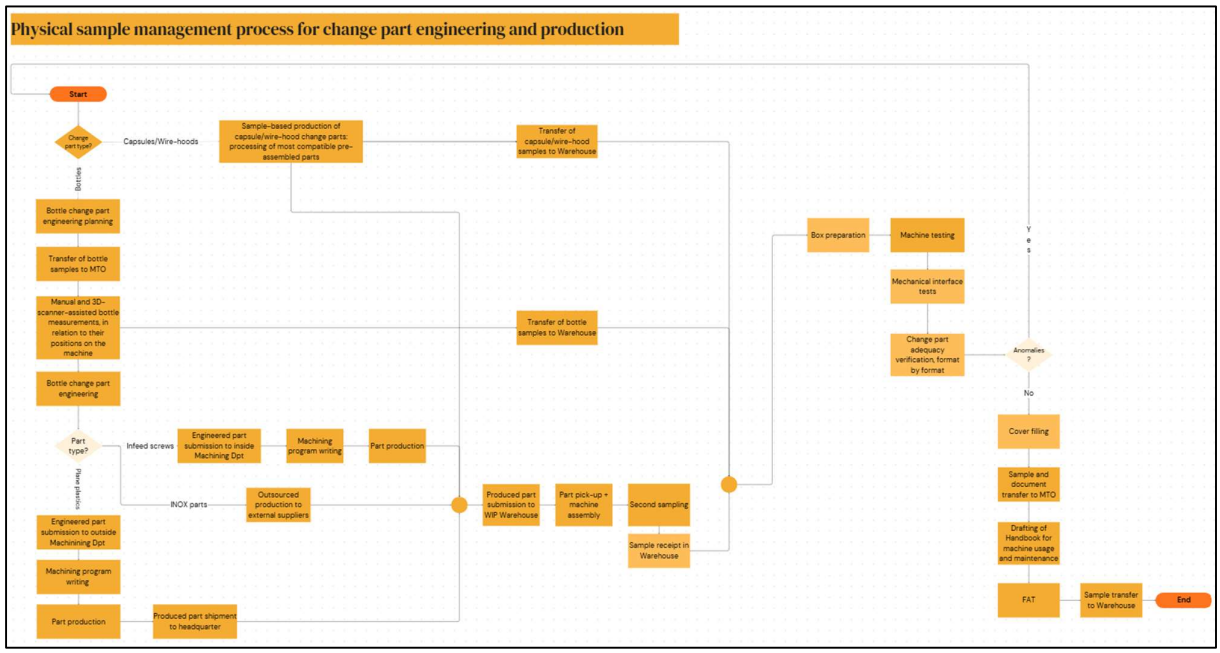
Quantitative and qualitative verification of bottleneck-shape shells / single-stage dowels and of ejectors: this control requires a capsuling test in Testing Room, aimed at verifying capsuling quality, which depends on the adequacy of the previously sold bottleneck-shape change parts. Basically, the test is performed to analyse the compatibility between the shell contained in the head and the bottleneck-shape of each format, so that to ensure that capsules are correctly inserted. To identify any possible combinations between the shell and the bottleneck-shape, whose pairing needs to be verified, a table is used as a support, where all key matchings are listed. Concerning this step, it is useful to specify that, in case the compatibility test between the capsule and the bottle previously turned out to be negative, technicians can anyway go on with this other control, by testing the pairing between a capsule, which is actually known to be suitable, and the considered bottleneck-shape change part. In doing so, the customer can be supported with some advice on how to adapt the initial capsule to the obtained results. After that, the identified shells are formalized, by also writing them on the label of the related bottle, to easily and immediately recognize them during final testing phase. In this step, in addition to shell definition, dependant on bottle format and capsule type, technicians also need to identify the necessary ejectors, since they also specifically vary according to bottleneck length. This other analysis is fundamental, since two scenarios can occur: it is possible to adopt some heads that already contain different dedicated shells, so that the ejectors can have a standardized height; alternatively, it may occur that the same head with the same shell is used, thus requiring to introduce some different sets of ejectors, which are dedicated, depending on the used bottleneck-shape shells *(Robino & Galandrino S.p.A, 2025)*.

Quantitative and qualitative verification of wire-hood distribution heads and of wire-hooding heads: to reach this purpose, it is needed to verify: bottle shape, particularly bottleneck length; bottle height, to assess their compatibility with the agreed machine model; the diameter related to the area under the support ledge, to determine the dimensions of the wire-hood ligation hook; cap dimensions, shapes and materials (generally cork or plastic), to assess whether they are compatible with sampled wire-hoods; wire-hood type, dimensions and shapes and their compatibility with sampled caps. At the end of this process, it will be possible to define total type and number of distribution heads that need to be produced; furthermore, technicians will evaluate the necessity of providing any special wire-hooding heads. Moreover, in case different hook types are required, because of bottles having different diameters related to the area under the support ledge, it is fundamental to immediately inform Commercial Office, and therefore the customer, since this scenario causes the necessity of replacing all hooks at each format change, which is a particularly complex operation *(Robino & Galandrino S.p.A, 2025)*.

3.4 CHANGE PART ENGINEERING AND PRODUCTION PHASE

In the following, in Figure 55, the flowchart related to this process phase.

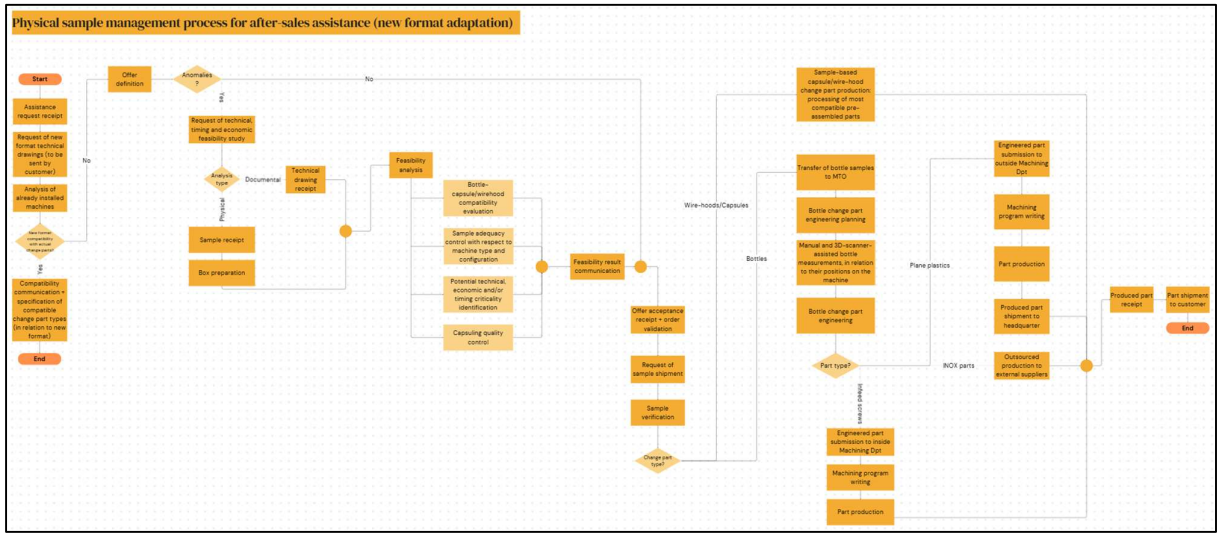
Figure 55 Engineering and production phase flowchart



3.5 AFTER SALES ASSISTANCE PHASE

In the following, in Figure 56, the flowchart related to this process phase.

Figure 56 After Sales Assistance phase flowchart



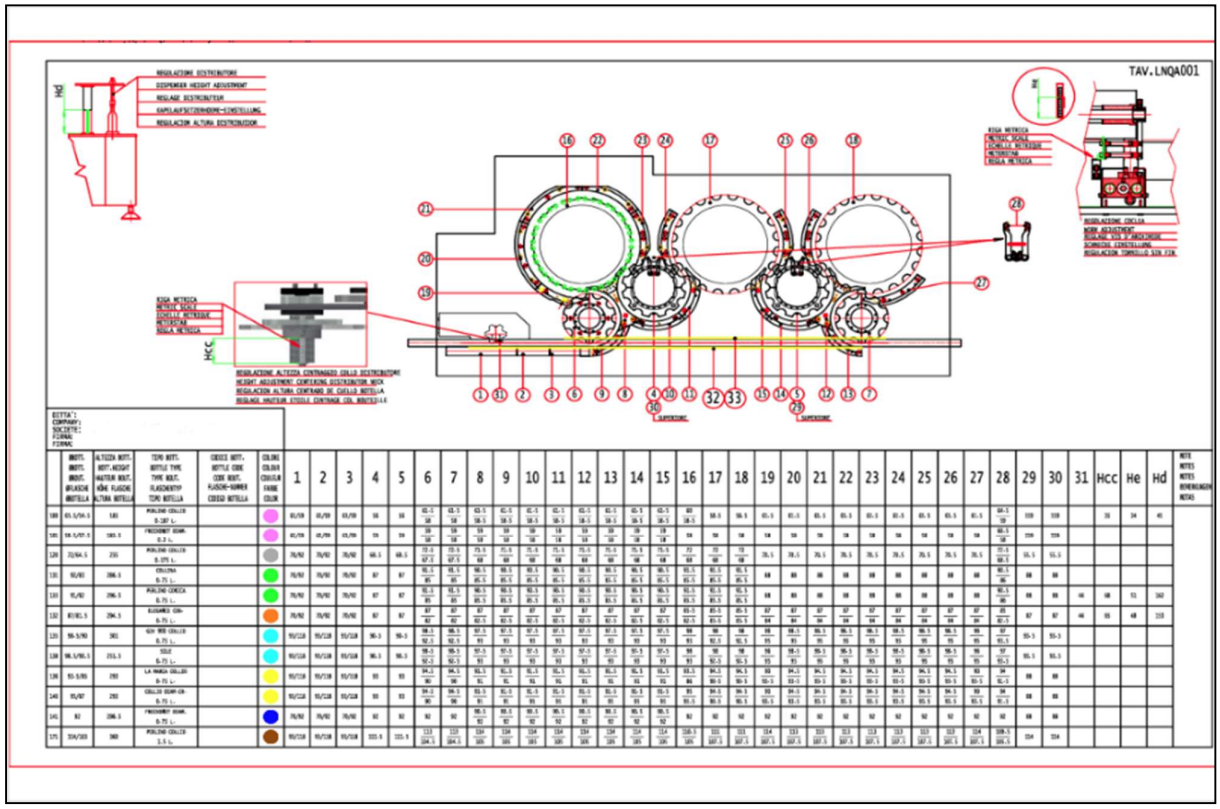
DESCRIPTION OF “COVER” STRUCTURE

As previously explained, the Cover is that part of the Handbook for machine usage and maintenance specifically concerning change parts, which is introduced to help the customer dealing with format changes.

To reach this purpose, some relevant files and drawings are therein introduced. The most important ones are:

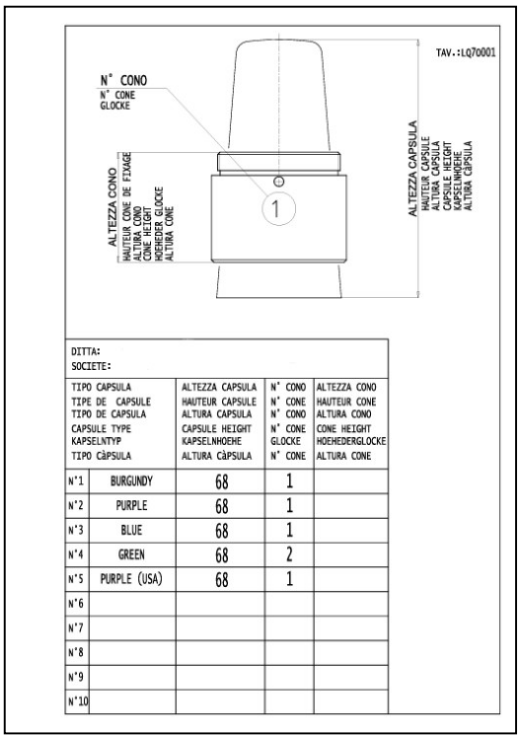
- Bottle change part file (see Figure 57) → bottle change parts are identified and distinguished through a colour code, which consists in reporting, for each one, its diameter, height, type (using the name chosen for it by the customer) and a specific associated colour - the idea is that those bottles that are categorized using the same colour are the ones that can share the same change part type;

Figure 57 Example of bottle format changes (Robino & Galandrino)



- Column file, for the different heads;
- Centring cone file, with these ones being identified by a number (see Figure 58);

Figure 58 Example of centring cone format changes (Robino & Galandrino)

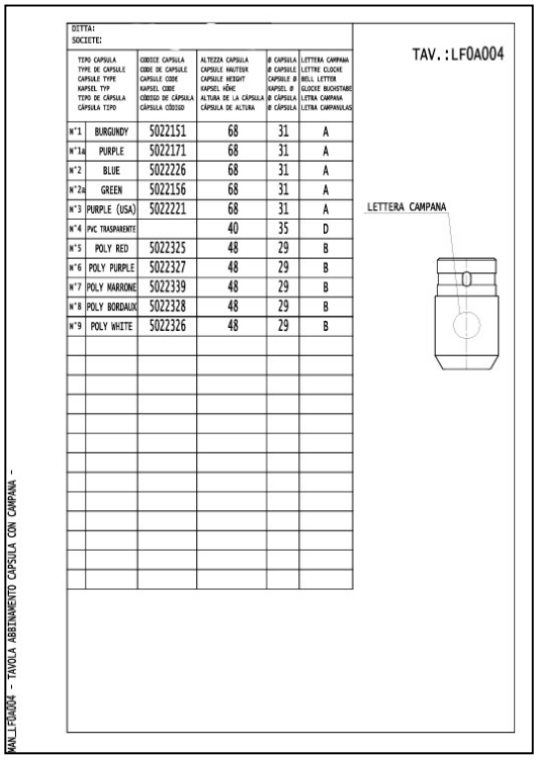


DITTA:
SOCIETE:

TIPO CAPSULA TYPE DE CAPSULE TIPO DE CAPSULA CAPSULE TYPE KAPSELNTYP TIPO CàPSULA		ALTEZZA CAPSULA HAUTEUR CAPSULE ALTURA CAPSULA CAPSULE HEIGHT KAPSELNHOEHE ALTURA CàPSULA	N° CONO N° CONE N° CONO N° CONE GLOCKE N° CONE	ALTEZZA CONO HAUTEUR CONE ALTURA CONO CONE HEIGHT HOEHEDERGLOCKE ALTURA CONE
N°1	BURGUNDY	68	1	
N°2	PURPLE	68	1	
N°3	BLUE	68	1	
N°4	GREEN	68	2	
N°5	PURPLE (USA)	68	1	
N°6				
N°7				
N°8				
N°9				
N°10				

- Capsule ejector file, with these ones varying depending on capsule type (PVC/PET, polylaminate/tin, specific for Spumante wine or specific for Spumante wine with medallion);
- Distribution bell file, with these ones being identified by a letter (see Figure 59).

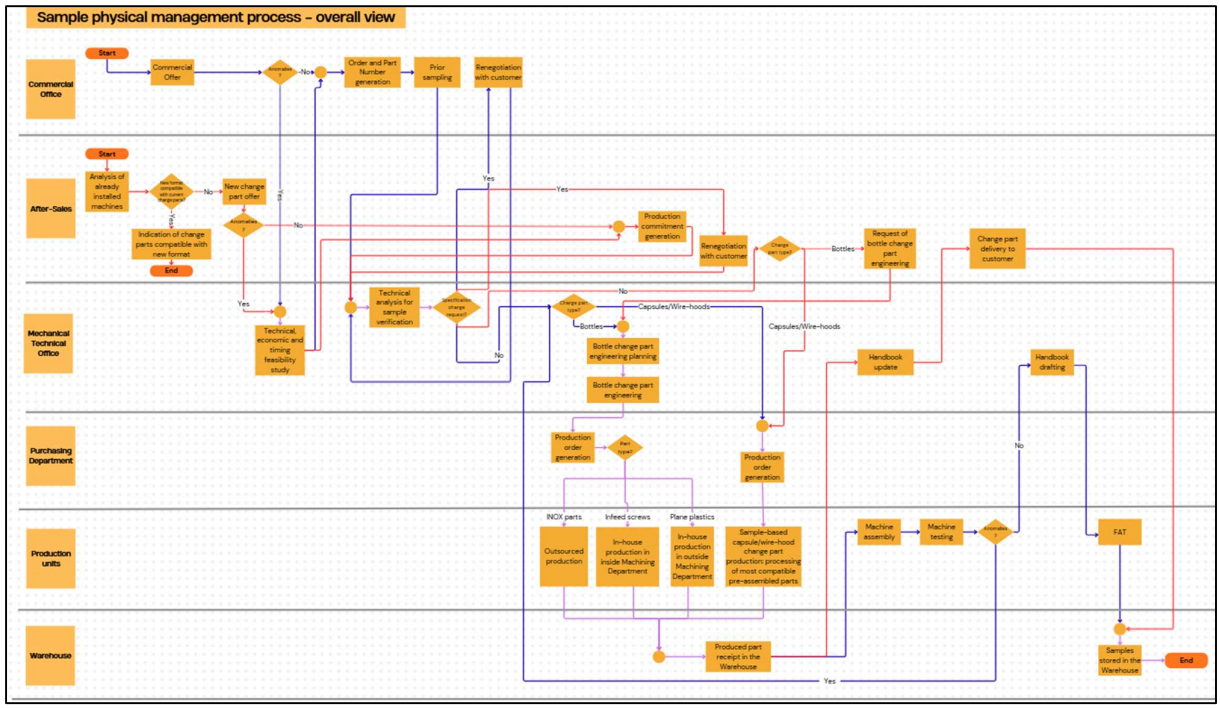
Figure 59 Example of distribution bell format changes (Robino & Galandrino)



3.6 OVERALL PROCESS VIEW

In the following, in Figure 60, the flowchart depicting the overall physical flow.

Figure 60 Overall physical flow

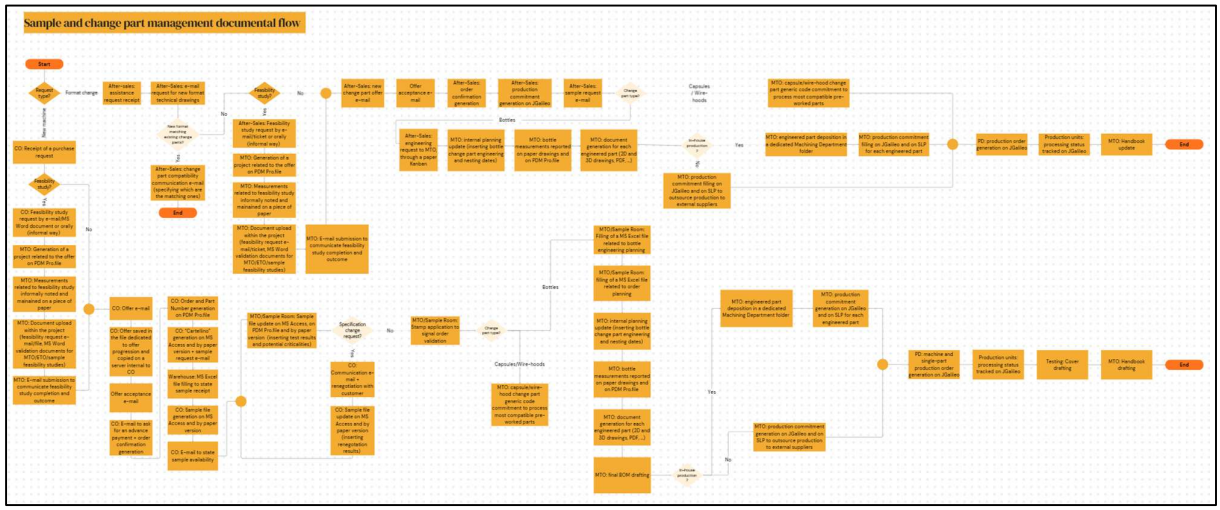


Concerning the graph above, it first needs to be pointed out that it was prepared with the aim of visualizing the whole physical flow. Therefore, it was decided to simultaneously show both the process related to new machines, the blue one, and the procedure concerning any requests for a new format adaptation, the red one. These flows were integrated together, in such a way to clearly identify those production functions and, particularly, those procedural steps, which are entitled to manage and satisfy both these request types in parallel. To better highlight this aspect, it was chosen to use a purple colour to represent those process sections where these two flows, the blue and the red ones, converge and go on at the same time.

Moreover, not to excessively complicate the visualization and comprehension of this diagram, all sample logistic transitions in the Warehouse were ignored. Clearly, this one has a crucial role in receiving and sorting samples once they are delivered, as well as in maintaining them until the end of this process, waiting for them to be picked up at the right moment to be verified. This role is highlighted in those more detailed flowcharts, specifically linked to each production step. On the contrary, this diagram was born as a synthetic summary of the whole flow; due to this aspect, the need emerged of ignoring some steps, with the aim of making the chart easy to read and of guaranteeing a more general analysis level.

In the following, in Figure 61, the flowchart depicting the overall documental flow.

Figure 61 Overall documental flow



For simplicity and visual clarity purposes, in both flowcharts, new machine commercial offer flow was represented as a competence in the hands of Commercial Office, since this one turns out to be the base-case scenario. Nevertheless, it needs to be recalled that it may sometimes happen that this process is carried out by the After Sales Assistance Department. This proves its crucial and strategic role, not only at the economic level, but also at the commercial one.

3.7 IDEF0 DIAGRAMS

In the following, in Figures 62-73, the already mentioned IDEF0 diagrams are reported. Concerning both these sets, some choices need to be justified to better understand and interpret these graphs.

First, it needs to be highlighted that *Sample File* was considered both as a control and as a resource. This choice arose because, on one side, it is used as a guide, since it defines all necessary data and indications needed to carry out the tests and to officially validate the order. On the other hand, it is also simultaneously considered as the tool by which all results are reported and stored. Therefore, considering its dual role in defining those parameters which tests should be based upon and in supporting their outcome traceability, it turns out to be classified both as a control and as a resource.

Moreover, in relation to the graphs that will be proposed in the following, it needs to be noticed that a paper kanban is always generated, for any document type. Therefore, to simplify the representation, this one was explicitly inserted as a resource supporting the process, only in case it is the only version by which the documentation is provided. On the other hand, whenever documents are also digitally made available, only these last ones figure as a resource, implying that their paper counterparts are anyway always generated.

NEW MACHINES

Figure 62 IDEF0 diagram: A-0 node

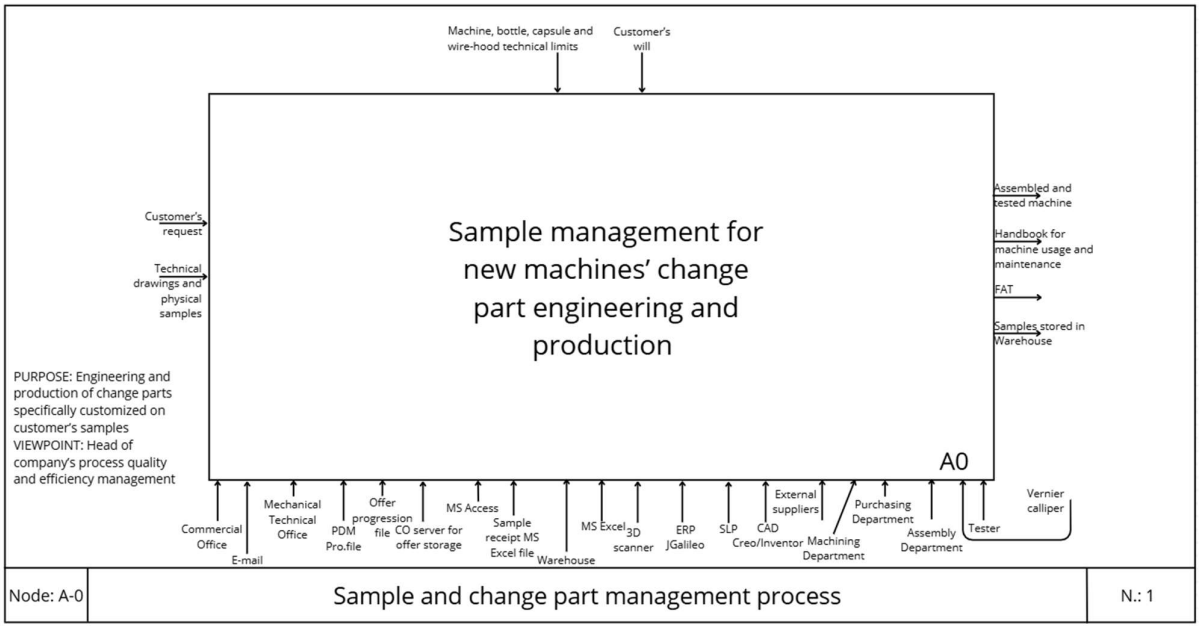


Figure 63 IDEF0 diagram: A0 node

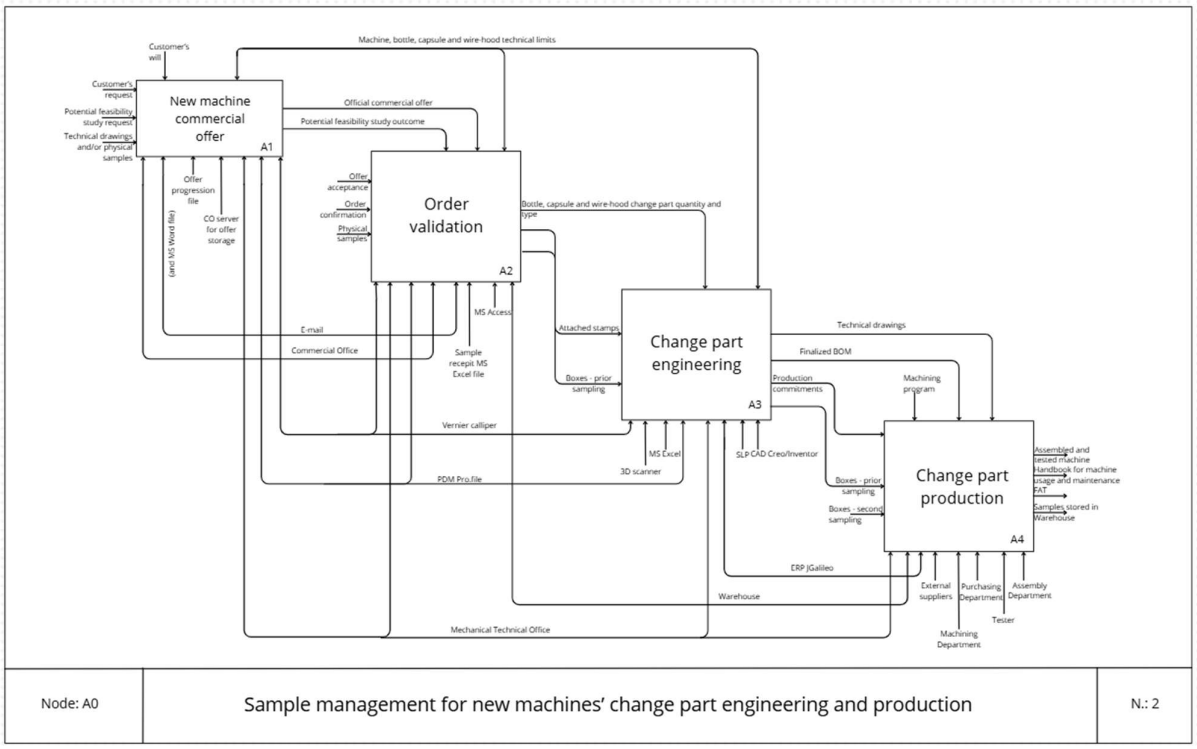


Figure 64 IDEF0 diagram: A1 node

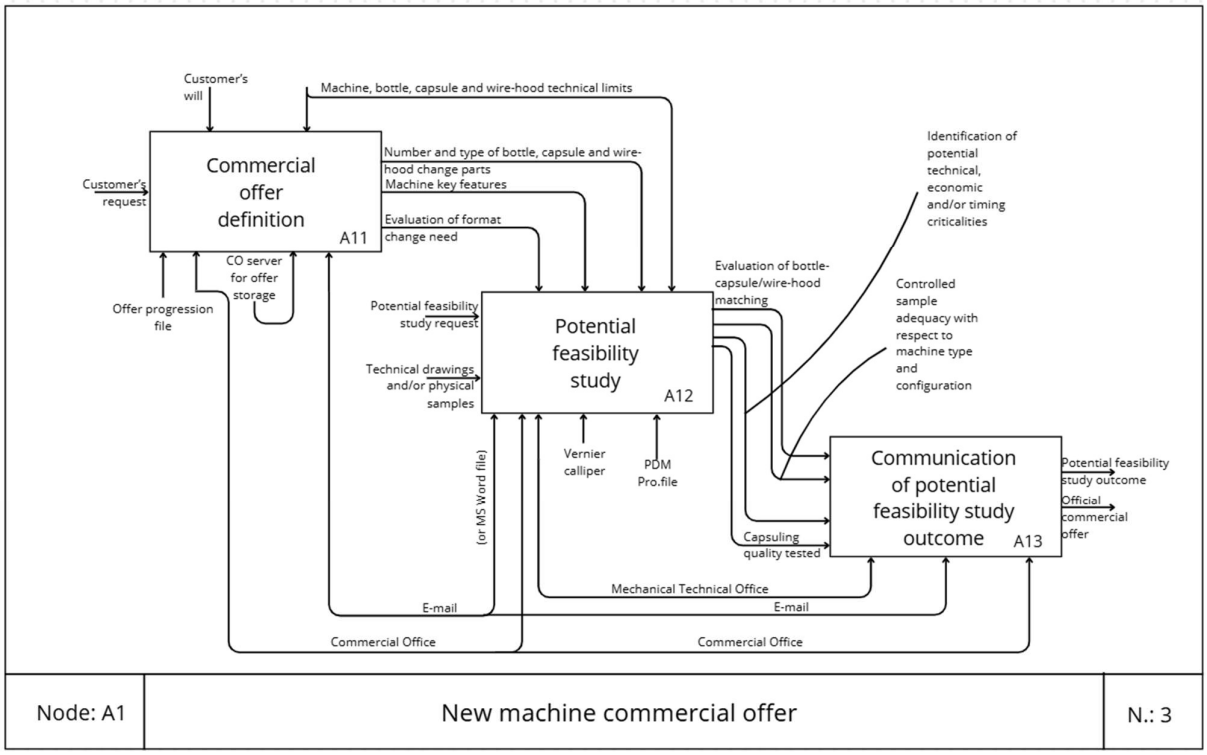


Figure 65 IDEF0 diagram: A2 node

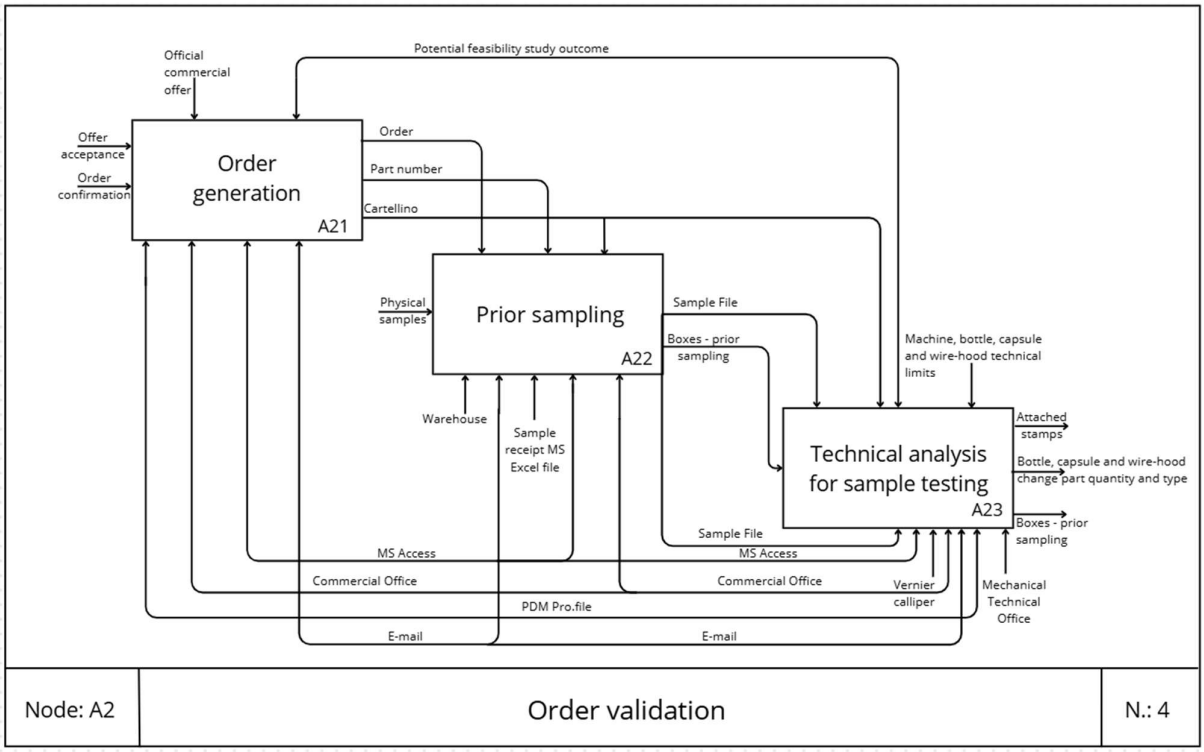


Figure 66 IDEF0 diagram: A23 node

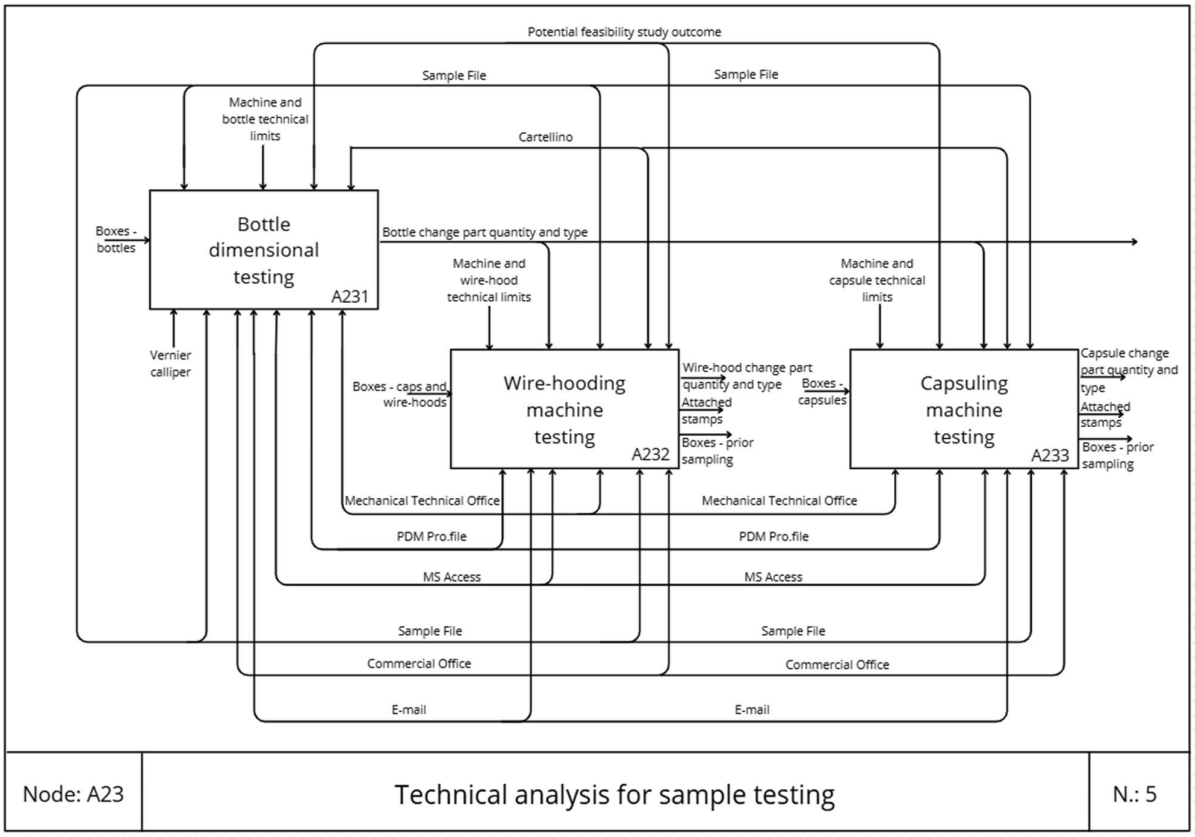


Figure 67 IDEF0 diagram: A3 node

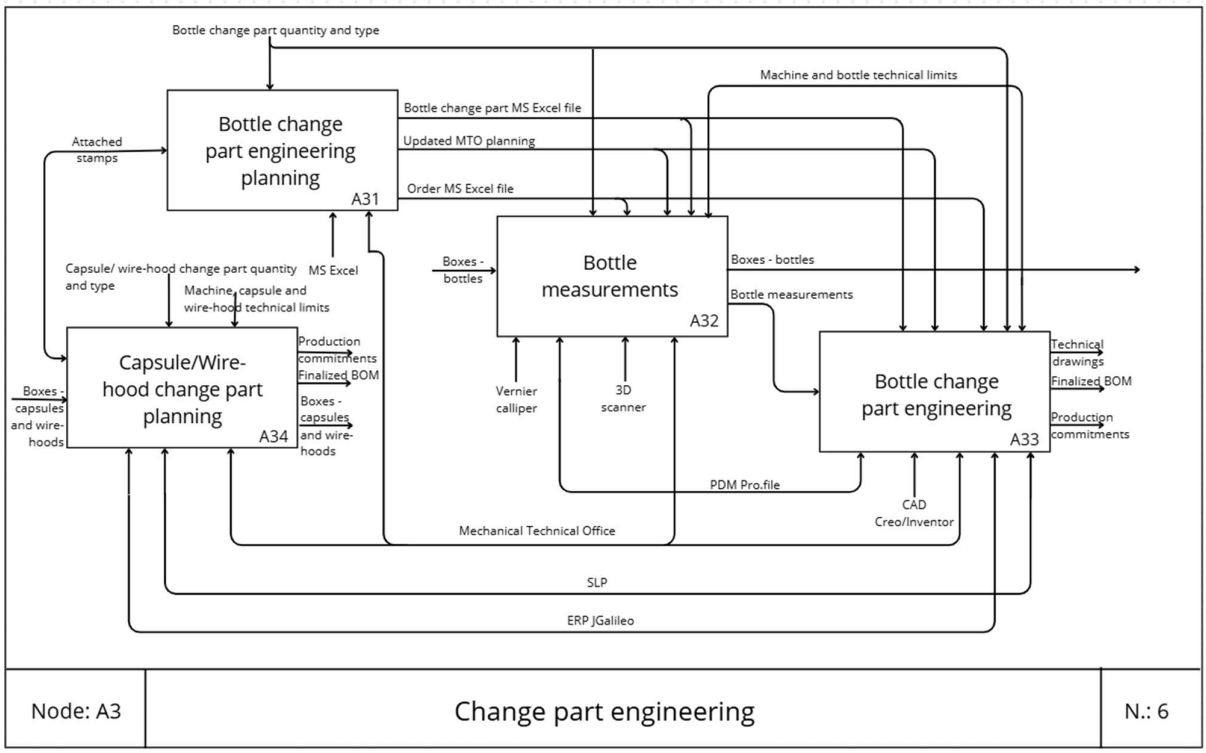
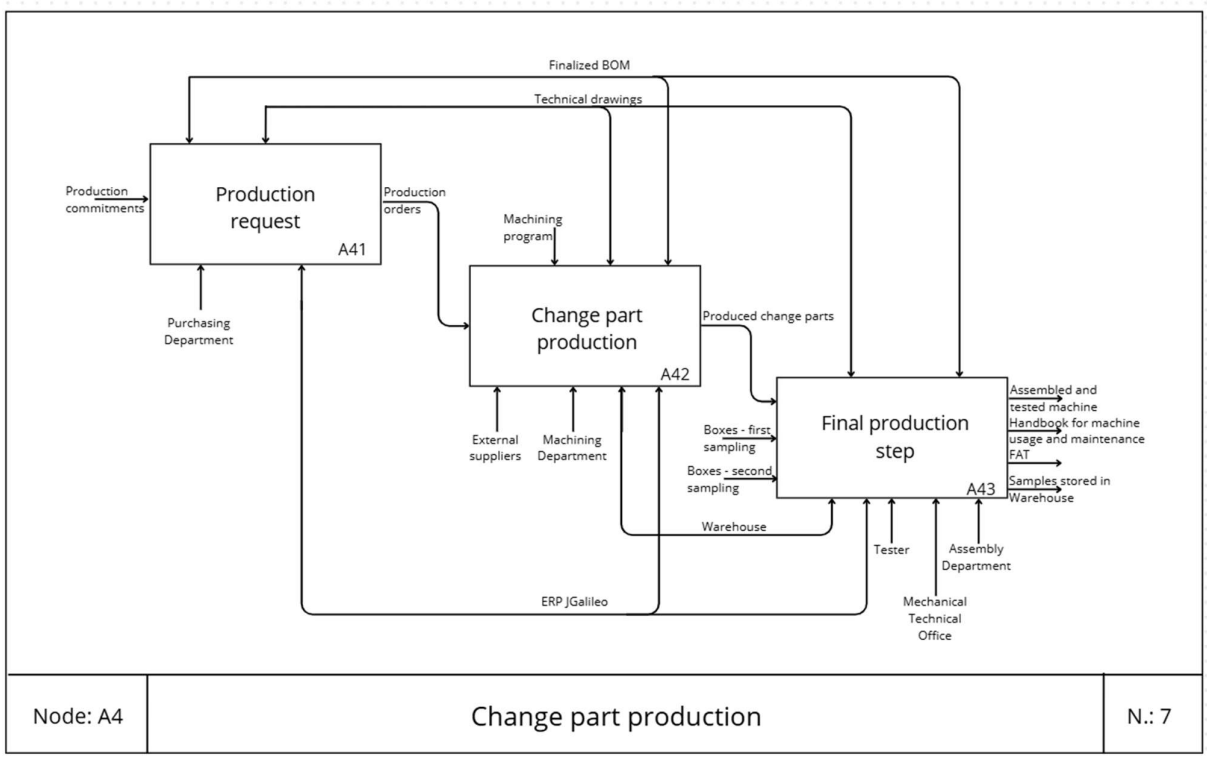


Figure 68 IDEF0 diagram: A4 node



NEW FORMAT ADAPTATION ON ALREADY INSTALLED MACHINES

Figure 69 IDEF0 diagram: A-0 node

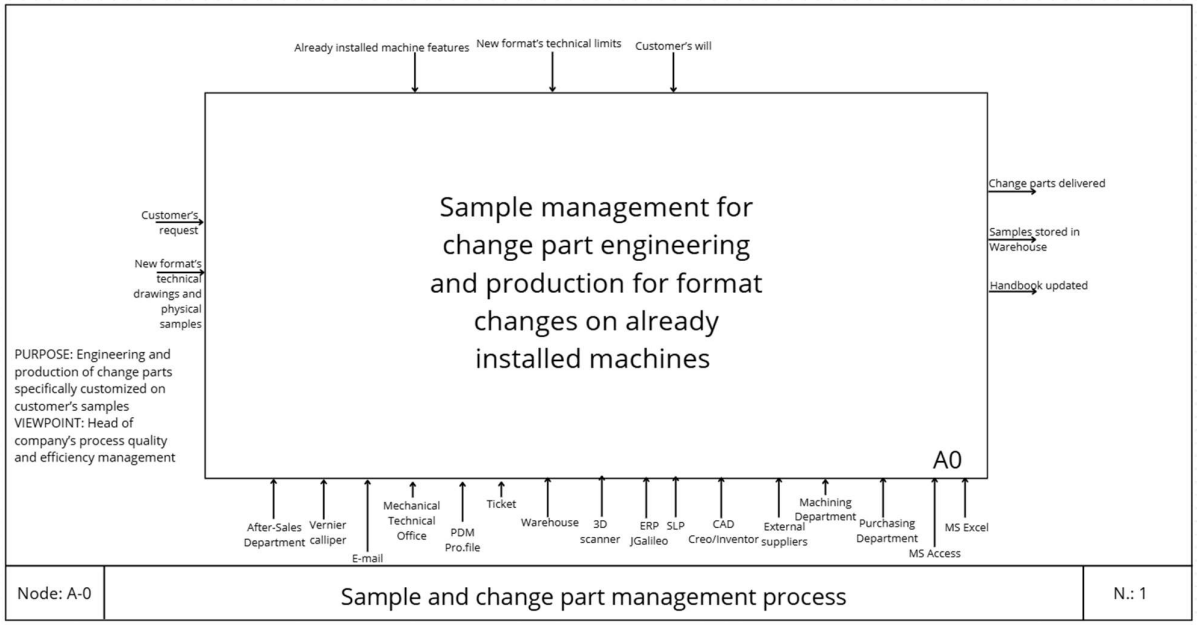


Figure 70 IDEF0 diagram: A0 node

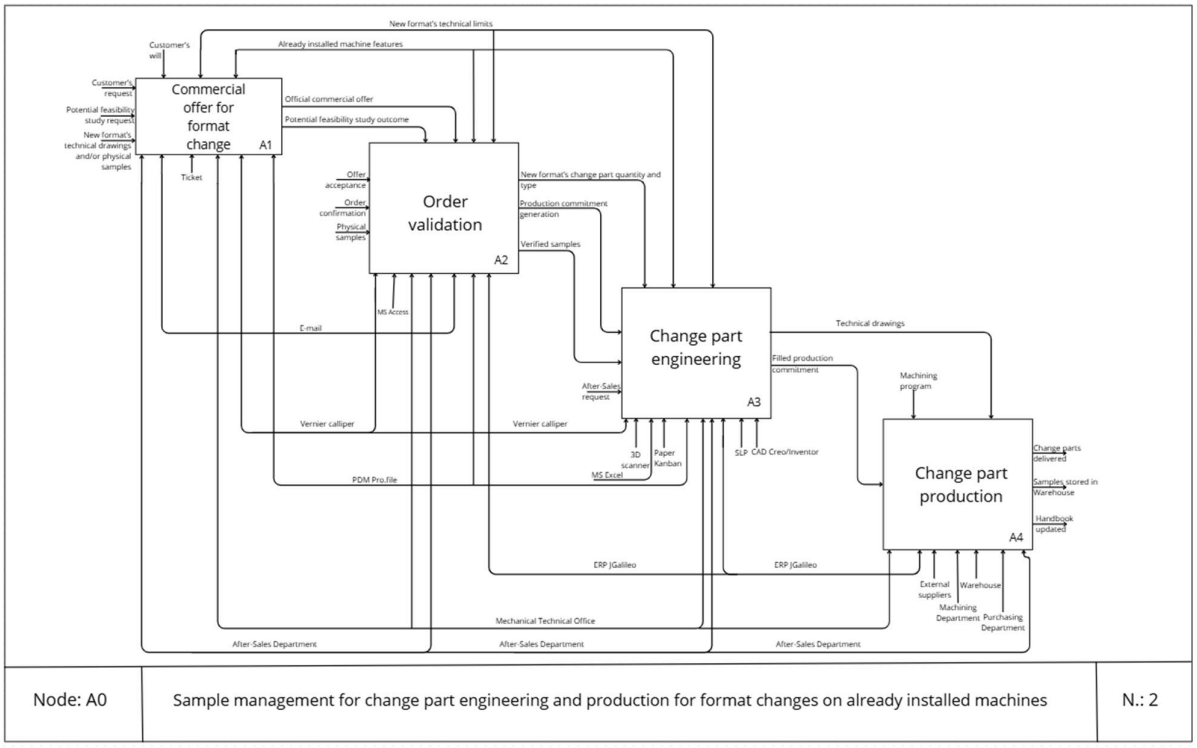


Figure 71 IDEF0 diagram: A1 node

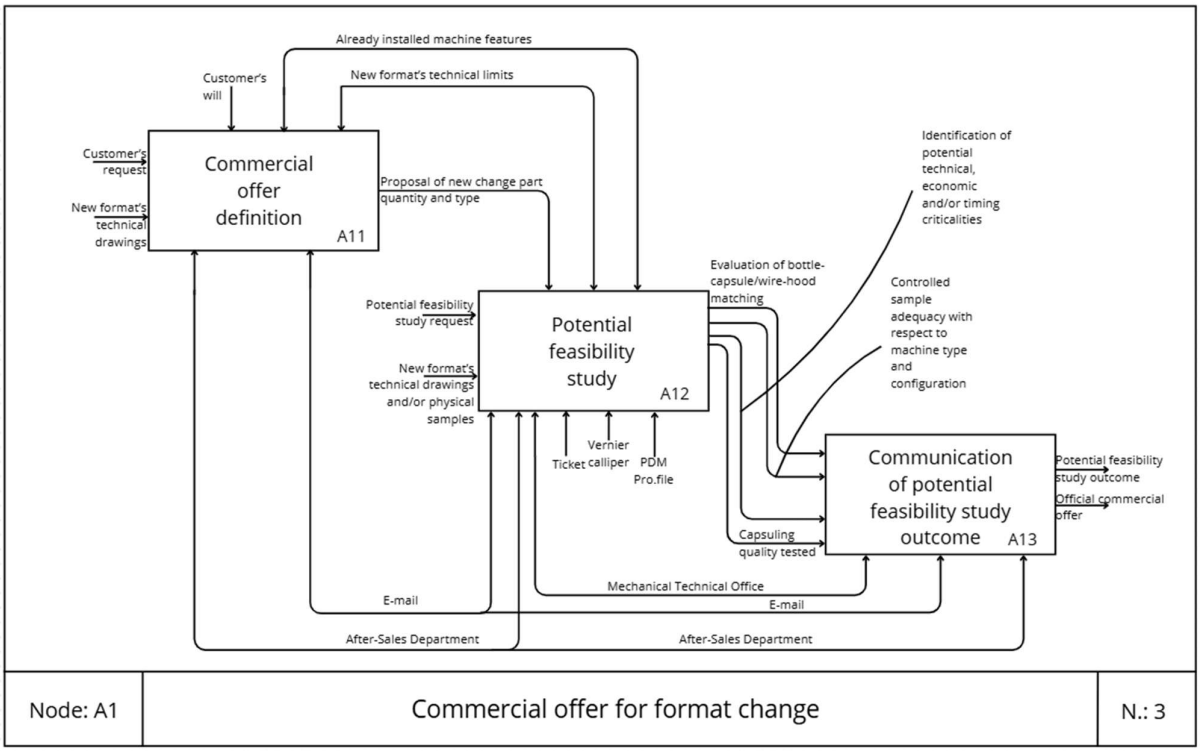


Figure 72 IDEF0 diagram: A3 node

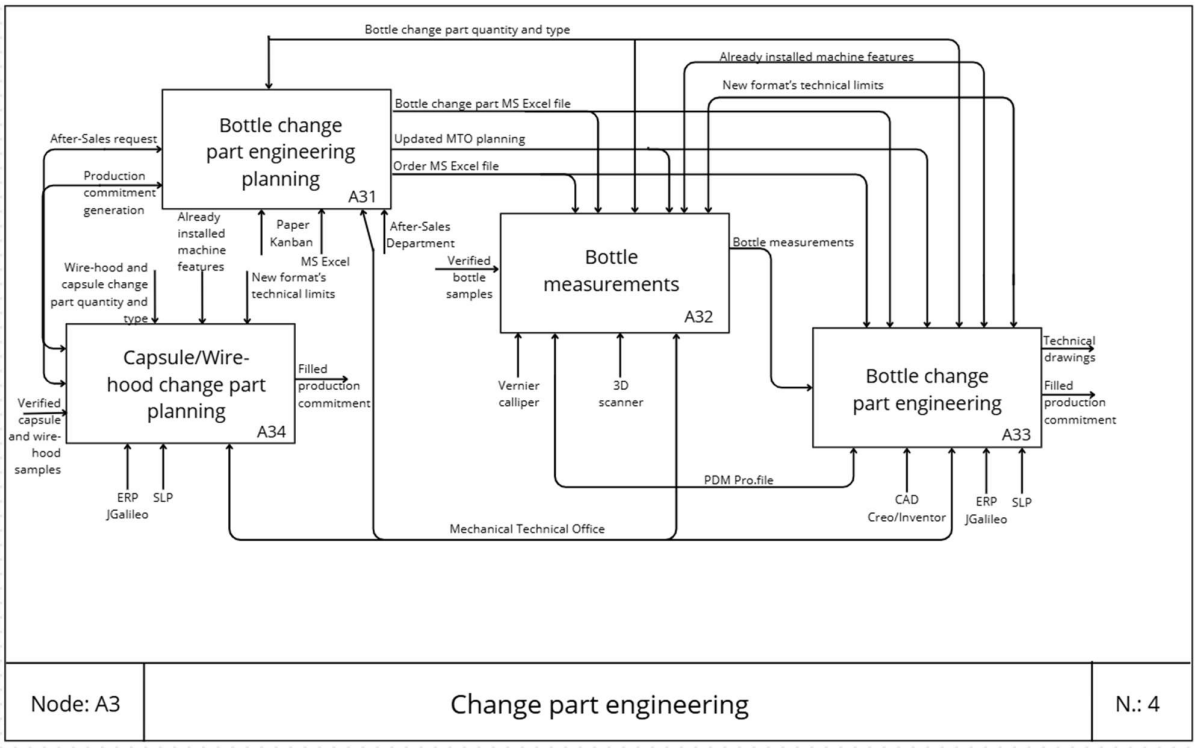
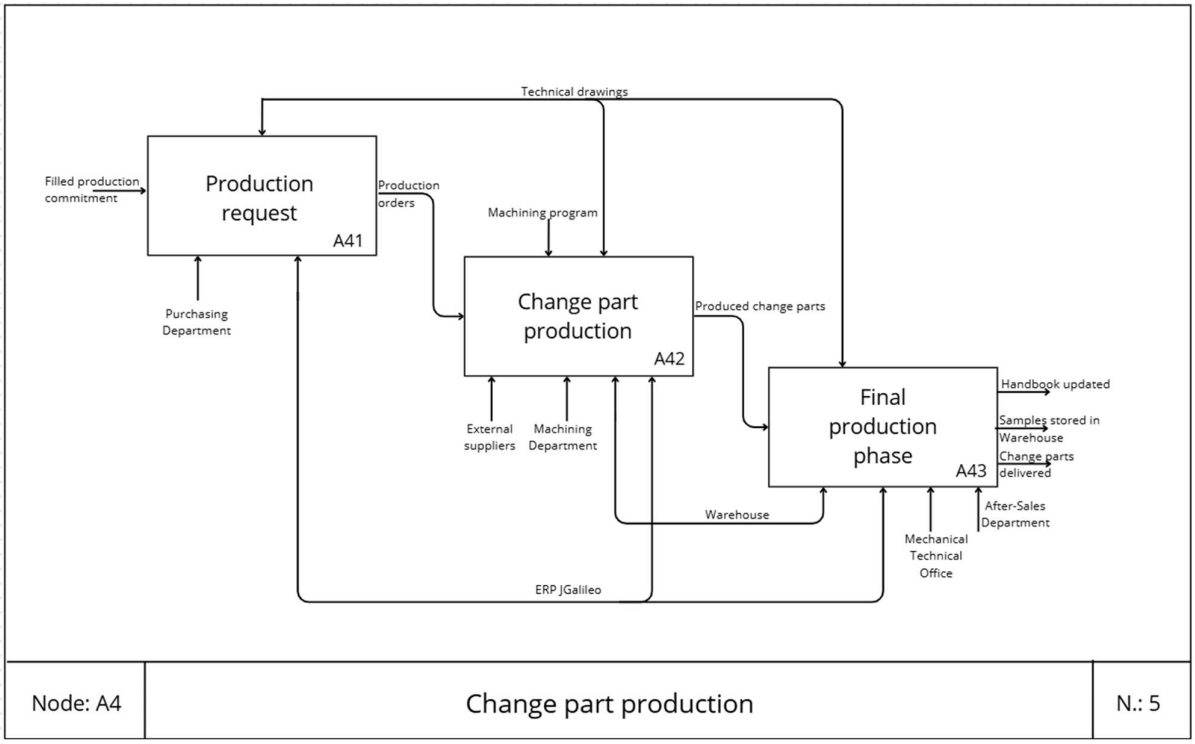


Figure 73 IDEF0 diagram: A4 node



4. CRITICALITY ANALYSIS

4.2 STRUCTURING OF EMERGED CRITICALITIES – *FMECA* DRAFTING

In the following, in Table 4, the *FMECA* analysis concerning process issues can be found.

Table 4 FMECA

ID	Failure mode	Effects	S	Failure cause	O	Detection system	D	RPN
1 – Feasibility study data centralization	Data related to feasibility requests and tests is not immediately and continuously updated: feasibility study requests are mainly centralized only upon MTO intervention, when it creates the offer project on its PDM; sample measurements are not formally saved in the ERP and made accessible for all.	No clear indication of this process phase current state, of its evolution and of the one of its related requests. Tests need to be performed again from scratch during order validation and handbook drafting phases. No possible direct consultation of feasibility analysis requests. →All these criticalities cause process time increase and efficiency reduction.	6	No official, structured, centralized and consolidated approach to monitor feasibility study state: data centralization and saving procedure concerning change part feasibility studies is an experimental one (only final outcomes are stored and maintained); feasibility study requests are often only sent via e-mail or orally (the official MS Word module is not filled in (CO) / the official ticket is not sent (AS)).	6	No official system to implement an alternative more structured and efficient iter as common practice → avoiding these effects to come up is very difficult. In case of feasibility study requests, a detection system is implemented when MTO informally receives the request and, before going on, requires commercial functions to formally fill in the official MS Word file/ticket.	8	288
2 – Inaccurate basis for feasibility requests	1.Feasibility analysis request is made concerning a case that has already been frequently managed in the past. 2.No feasibility study request, even though this one is needed.	1.Working hours are planned for a non-necessary request → waste of time; efficiency decrease; cost increase. The order may not be finalized because of the prolonged waiting time for feasibility study outcome to be received → significant cost impact and customer's loss, arising because of a totally avoidable scenario. 2.Relevant offer aspects are not properly and exhaustively analysed → major sample-machine non-compatibility issues emerging at an advanced process stage, when they are not easily negotiable with the customer → difficult and costly management and resolution; reputational losses.	8	Superficial definition of the conditions according to which technical feasibility studies should be requested (they are based upon a simplistic and not fully correct table).	6	Workers' ability to quickly recognize clear issues and similarities with past orders: because of the lack of specific and precise conditions upon which feasibility requests can be based, to avoid these criticalities to emerge, the only detection system lies in the experience of those workers entitled to sales management and test performance.	8	384

3 – Lack of order confirmation phase	Offer critical and relevant aspects do not emerge while defining it, but only at already mature process stages, when they are not easily negotiable with the customer.	Difficult order and customer-relationship management. Reputational losses. Extra-costs.	9	Superficial contractual aspect management: order confirmation phase is superficially defined and managed; lack of a formalized and official commercial offer validation phase, before this one becomes an order (before the order undergoes production stages, there is an order validation step, whereas a similar phase is not introduced before the commercial offer becomes an order).	5	Workers' ability to evaluate different alternatives and quickly recognize when it is needed to ask for MTO's support: because of the lack of an official offer validation step, to avoid these criticalities to occur, a detection system lies in the experience of workers entitled to sales management. Feasibility study phase can compensate for the absence of the order confirmation/offer validation step: whenever it is requested, it allows to evaluate all most critical aspects by time.	7	315
4 – Discrepancies between the two sampling groups	Any machine is engineered starting from the samples delivered in the initial order validation phase. So, if these ones differ from the ones sent for machine final testing and reveal not to be compatible with the already produced change parts, major issues arise in relation to machinery compatibility with the products to be worked on it.	This issue emerges at an already advanced process stage, when machinery production is almost concluded → Re-processing; Extra-costs; Delays.	9	Substantial dimensional differences in the samples that the customer delivers in each of the two phases, leading to major discrepancies and non-compatibilities in the two sample groups.	4	Bottle, capsule and wire-hood technical drawings are sent together with physical samples in the prior-sampling phase → increased accuracy and better tolerance control → improved format adaptability to machinery, also if some inaccuracies and/or physical discrepancies occur; increased easiness in proving that the company is not responsible for any non-compatibilities.	6	216
5 – Delayed sample delivery	Delayed sample-machine compatibility analysis and potential negative outcome of this one.	Delays. Efficiency losses. If the outcome is negative, extra-costs to adapt machinery to delivered samples (particularly critical scenario if process is found at an already advanced status).	8	Significant delay on customer's side in delivering samples → condensation of prior-sampling and secondary-sampling phases.	4	Contractual clauses and reminders, so that to have the customer deliver samples by a specific X date and to make him responsible for all delay-related issues.	5	160

6 – Box preparation	1.Time increase in preparing boxes. 2.Some sample types are not detected and picked up.	1.Efficiency losses; cost increase. 2.These sample types are not considered in determining the number and type of change parts needed for the machinery → extra-costs and delays, if these formats require some dedicated change parts, which were not initially introduced and which need to be added and negotiated ex-post.	7	Pallets are loaded in a superficial and casual way because of customer's inattention and carelessness.	6	Cross-check to verify that any bottle/capsule/wire-hood formats figuring in the order are picked up. Limitation: this still causes a loss of time.	6	252
7 – Manual sample technical analyses	1.Increase in the time needed to perform these tests, particularly when considering bottleneck-shape change parts (lots of possible combinations to be individually tested). 2.Increased probability of making some major mistakes.	1.Increase in the time needed to validate the order. Opportunity cost related to the time that may have been allocated to more value-added activities. 2.In case of mistakes, incompatibility issues between change parts sold and formats to be worked.	7	Manual controls, based on physical samples.	7	Table showing all main possible combinations between shells and bottleneck-shape change parts, so that to make matching tests easier and quicker. Limitation: these are not fixed and sure scenarios → many attempts may still be required, before finding the right combination. Technical drawing request, so that to detect more accurate, reliable and univocally defined measures and reduce the error rate.	5	245
8 – Defective and missing part late detection	Qualitative defects and/or missing parts are detected at a mature process stage.	Ex-post need to search for missing parts and to re-process some components → process and final delivery delays; extra-costs (especially for particularly critical items).	8	Critical social and educational context → increasingly less trained and prepared workforce, both for internal processes and for external ones. Lack of an official phase to quantitatively control produced parts, except for mechanical components. Lack of a process step and of a professional role specifically entitled to quality controls, which are only visually made (measures are not controlled until final assembly step).	6	No control method alternative to the currently used one → if a defective item and/or a missing part occurs, with the actual system, it is not possible to detect it by time, but only close to final production step, leading to the depicted effects.	10	480

9 – Database misalignment (both concerning the one for engineered change part drawings and the order one)	Divergencies between digitally and paper-based stored data → these two databases are not aligned, and the digital one is incomplete.	Engineering mistakes emerging because of technicians considering the non-updated database version → engineering of obsolete components → quality and efficiency losses. A component which has already been drawn for a past similar order is re-engineered from scratch → time and efficiency losses. Missing analysis of what has been sold in the past for the same order (in case of a format change) or for a similar one → commercial offer consisting in non-optimal or inadequate change parts.	8	Missing or non-constant digital database update (some of the data is still only maintained in its paper-based version).	5	Cross-control of both databases for any new request. Limitation: this still causes a loss of time. Workers' experience: capability of quickly recognizing key similarities with past orders.	7	280
10 – External production site management	Logistic burdens. Material losses along production line. Components belonging to different orders are mixed up together.	Direct transport costs. Indirect costs due to material losses along production line and to lead time increase. Delays due to the time needed to ex-post identify those components belonging to different orders, which are mixed up together, so that to allocate them again to their initial destination.	7	In-house production but organized in a different manufacturing site. No precise areas near the pantograph, specifically distinguished depending on the order and aimed at part sorting. Lack of a professional role specifically entitled to this external site production and logistics management.	5	No current alternative methodology and no available detection system → if a component is mixed up or missing, with the currently used system, it is not possible to detect it by time, but only close to final production step.	10	350

11 – Sample-based change part production	1.Different change part types are sold to process the same capsule/wire-hood format. 2.Inadequate change parts are sold. 3.If a change part is restored: need to repeat process flow from scratch → need to ask again for product samples and to measure them again.	1.If the company is dealing with the same customer: useless offer to buy a change part that he already owns → reputational losses; in extreme cases, customer's loss. 2.Quality and reputational losses; delays; in extreme cases, customer's loss. 3.Extra-costs and time; criticalities due to sample receipt and control connected phases may occur; possible customer's loss, if the company does not stick to the required delivery times.	9	Sample-based production, with an assembly-to-order logic.	5	Workers' ability to quickly recognize clear issues and similarities with past orders: the only detection system lies in the experience of workers entitled to sales and sample analyses.	8	360
12 – Too long change part offer phase for format changes	If the customer does not accept the offer, sunk costs increase.	Significant financial losses.	7	Change part offer phase for format changes is too prolonged in time.	4	No mechanism to reduce failure impact → if the offer phase lasts too long and the customer rejects the offer, sunk costs will naturally and inevitably grow up.	10	280
13 – Lack of a formalized change part list	Confusion concerning what is included in "change part" definition and how different ones need to be distinguished and paired, depending on machine and product specifications.	Misalignment between different functional units. No structured formalization of all elements that need to be evaluated and handled during the process → efficiency losses.	6	Lack of an official change part list, distinguished by machine and product. Different words used to refer to the same change part type.	9	Handbook sections that better define the existing different change part types represent a starting point to understand which are change part kinds and how they are usually paired.	5	270

In the following, in Figures 74 and 75, respectively, the *Risk Matrix* and the *Pareto Chart*, which were drafted starting from the *FMECA* table.

Figure 74 Risk Matrix

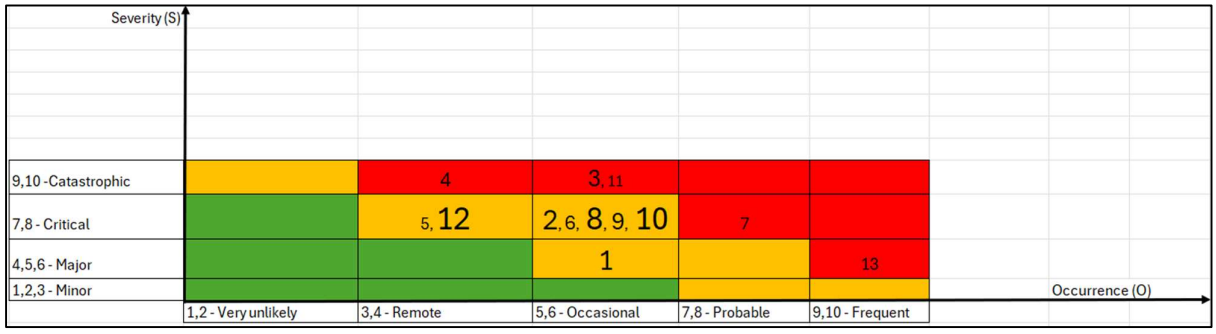
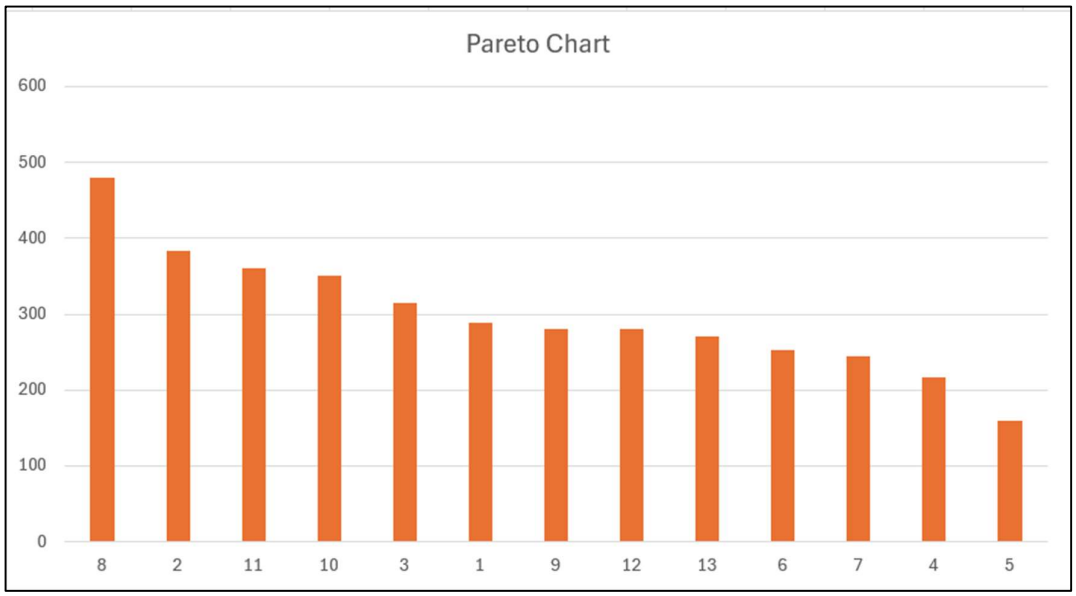


Figure 75 Pareto Chart



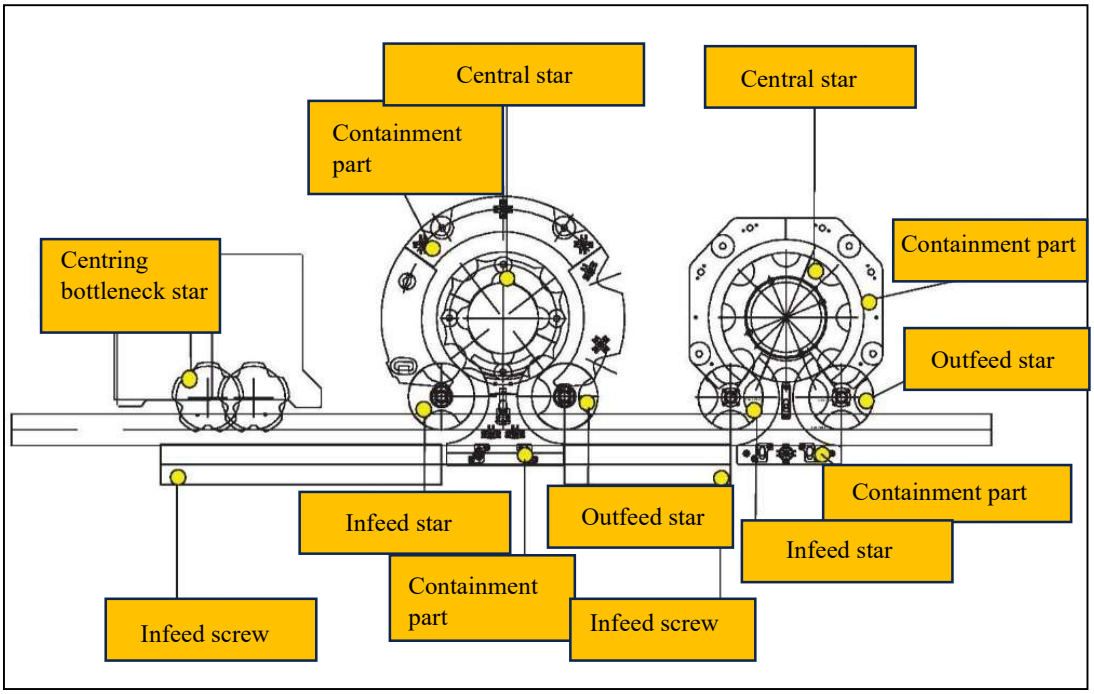
5. IMPROVEMENT PROPOSALS

5.2.3 CHANGE PART LIST DRAFTING

GENERAL COMPONENTS

In the following, in Figure 76, an overall picture of the change parts generally used on any machine type to process bottles is reported. It is to be noticed that when reading "containment parts", drawer sides and conveyors are concerned.

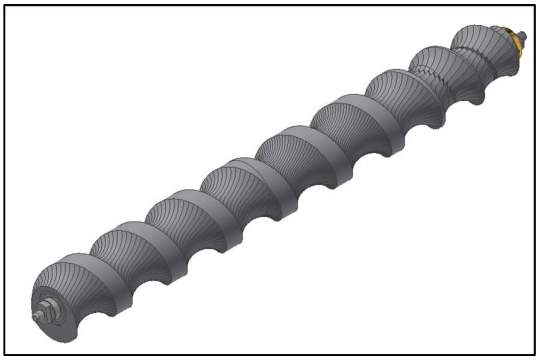
Figure 76 Overall picture of bottle change parts (Robino & Galandrino)



By detailly analysing these elements, the following bottle change part list could be obtained *(Robino & Galandrino, 2025)*.

- Infeed screw (see Figure 77), being subject to the rules of Table 5 and classified into two types:
    - Standard: requiring tilting motion;
    - Universal: requiring support and motorization + verification of the standard range which sampled bottles need to comply with;

Figure 77 Infeed screw (Robino & Galandrino)



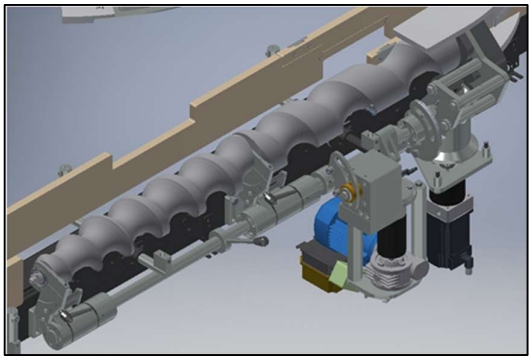


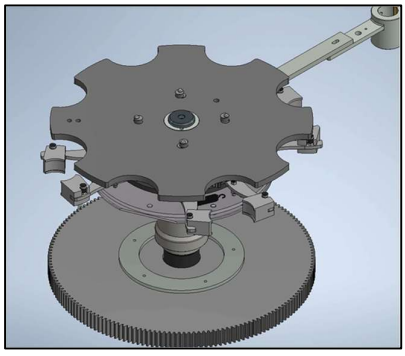
Table 5 Infeed screw number, depending on machine specifications (Robino & Galandrino)

Machinery speed	**Max diameter tolerance**	**Practical rule**	**Impact on change part number**
< 5000/6000 bott/h	4/4,5 mm (only if the bottle is a cylindrical or conical one)	1 infeed screw for each 4/4,5 mm range	Infeed screw number < Drawer side number
≥5000/6000 bott/h	-	1 infeed screw for each format	Infeed screw number = Drawer side number

- Centring bottleneck star;

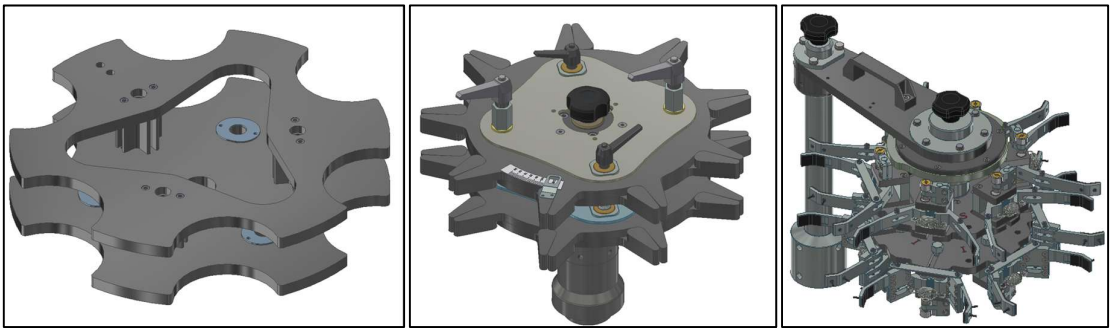
- Transfer star (see Figure 78): with clamps, it is used to keep the bottle centred and aligned, thus avoiding its uncontrollable rotation;

Figure 78 Transfer star (Robino & Galandrino)



- Infeed, central and outfeed stars (see Figure 79), to be distinguished into the following categories:
    - Standard: dedicated cavity;
    - Variable-geometry: universal star, consisting of two independent phases, so that to even work bottles showing different diameters – it is sufficient to adjust them at their superior and inferior sides, without never changing them;
    - With clamps: universal star, equipped with a clamp regulated by a cam, so that it autonomously closes on bottle actual diameter, without even requiring a human operator to intervene;

Figure 79 Different star types. From the left to the right: standard, variable-geometry, with clamps (Robino & Galandrino)



- Spacers (see Figure 80): if bottles are particularly high and unstable, these components can be higher than the standard ones;

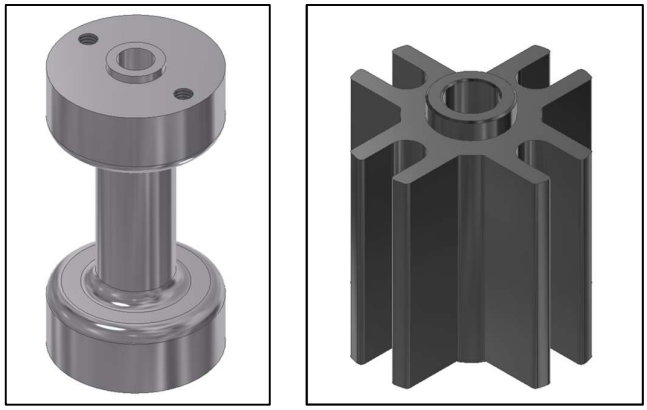
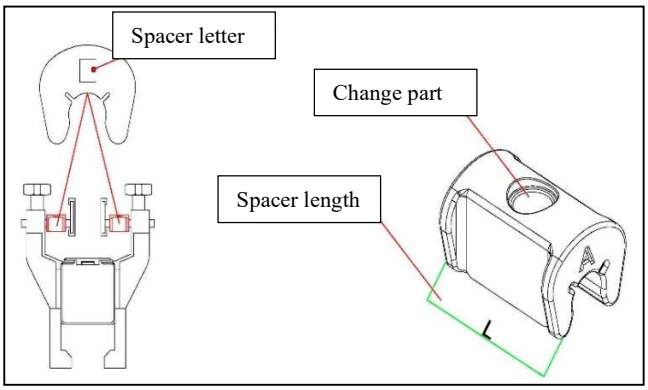
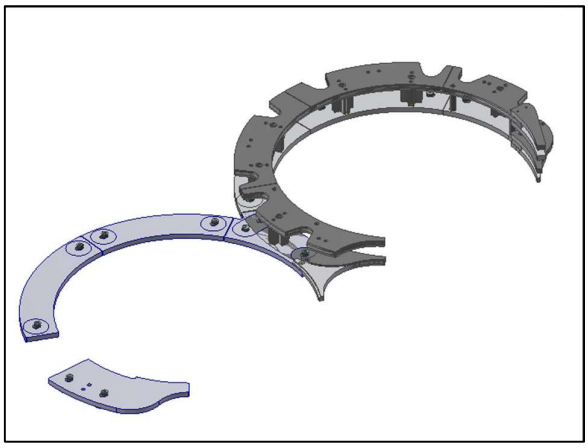


Figure 80 Spacers (Robino & Galandrino)



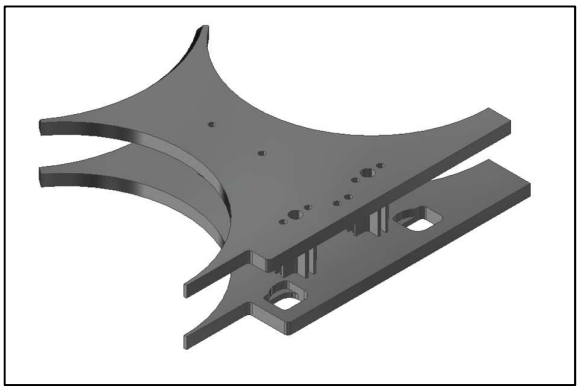
- Drawer sides (see Figure 81): if bottles are particularly high and unstable, these components can be doubled in number along bottle feeding belt;

Figure 81 Drawer sides (Robino & Galandrino)



- Conveyor (see Figure 82).

Figure 82 Conveyor (Robino & Galandrino)



To conclude this first section, two assemblies are reported: the first one, in Figure 83, concerns containment parts (drawer sides and conveyors), while the second one, in Figure 84, shows all bottle change part types.

Figure 83 Containment part assembly (Robino & Galandrino)

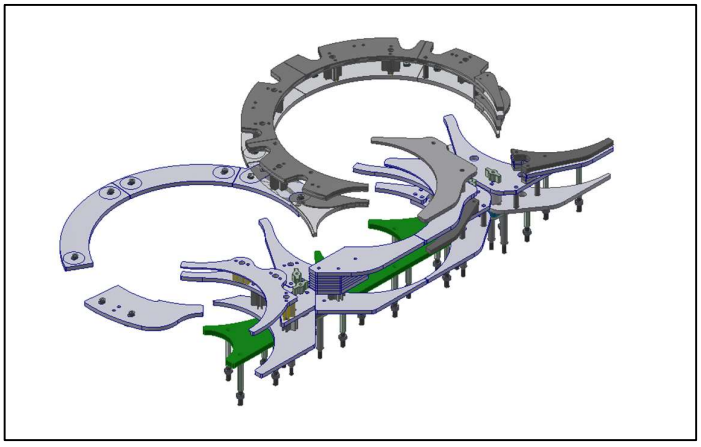
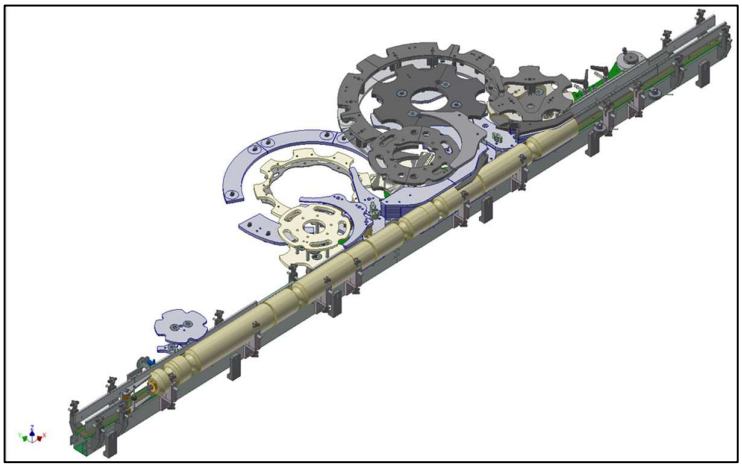


Figure 84 Bottle change part assembly (Robino & Galandrino)



PROCESSING-DEPENDENT COMPONENTS

WIRE-HOODING MACHINES:

The following wire-hood change part list was obtained *(Robino & Galandrino, 2025)*.

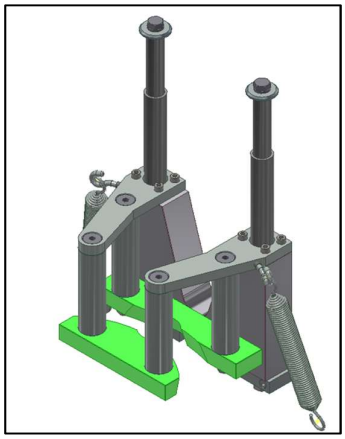
- Wire-hood distribution or catching head (see Figure 85): it is used in wire-hood distribution phase;

Figure 85 Wire-hood distribution head (Robino & Galandrino)



- Clamp locking dowels (see Figure 86);

Figure 86 Clamp locking dowels (Robino & Galandrino)



- Wire-hooding head (see Figure 87);

Figure 87 Wire-hooding head (Robino & Galandrino)



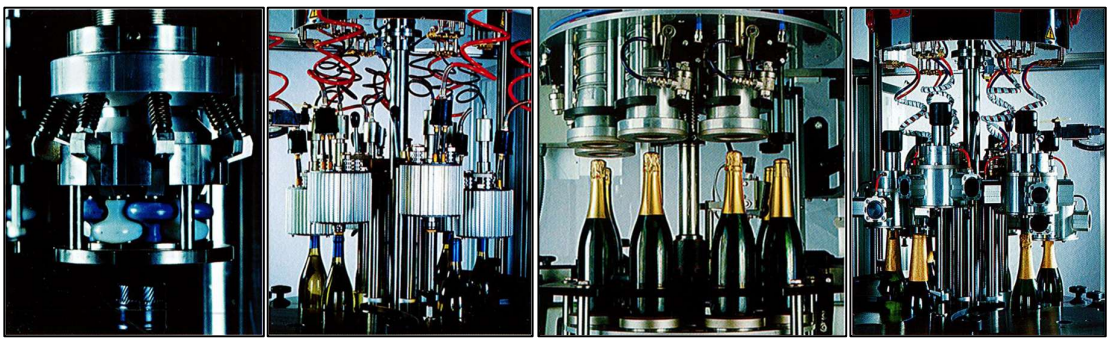
- Ligation hook, being of two types:
  - Standard: D.8,5 mm, used for wire-hoods having a standard diameter of the area under the ligation hook (29-30,5 mm);
  - Dedicated: its measures are indirectly proportional to those of the area under the ligation hook, used for wire-hoods having a non-standard diameter of the area under the ligation hook.

CAPSULING MACHINES:

The following capsule change part list was obtained *(Robino & Galandrino, 2025)*.

- Processing heads (see Figure 88), being of different types, can sometimes be interchanged on the same column, for example when dealing with Single-Stage or Superbloc machines, and are distinguished as follows:
  - Thermal: used for heat-shrinkable capsules and satin or "T" caps (rarely for mushroom caps or wire-hoods);
  - Rolling: used for polylaminate/tin capsules and satin or "T" caps;
  - Pneumatic: single-stage (lower quality) or bi-stage (higher quality), used for Spumante large capsules and mushroom caps or wire-hoods, almost always requiring optical centring (colour-variance or UV one). In case of single-stage pneumatic heads, it is enough to replace the dowels and occasionally the ejector, while the whole head only requires to be changed if a 0,187 Lt bottle is being processed, which needs some dedicated heads;

Figure 88 Different head types. From the left to the right: rolling heads, thermal heads, single- and bi-stage pneumatic heads (Robino & Galandrino)



- Eolo bi-stage pneumatic heads: depending on bottle and capsule formats, a dedicated group is assigned (equipped with shell, ejector, etc…), in such a way to process bottle-capsule pair at best, ensuring a finished high-quality level. In this case, the ejector needs to be replaced, since the same head can fit some ejectors equipped with different spacers, whereas the whole head only requires to be changed if shell format is different;

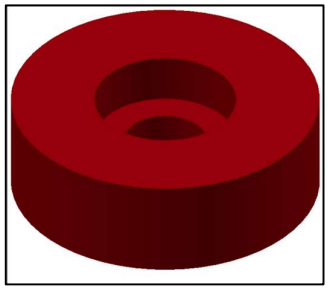
- Roller for rolling heads (see Figure 89): this component is mounted on rolling heads and is selected based on capsule material composition, for example depending on whether this one is harder or more fragile;

Figure 89 Roller for a rolling head (Robino & Galandrino)



- Pad for thermal heads (see Figure 90);

Figure 90 Pad for a thermal head (Robino & Galandrino)



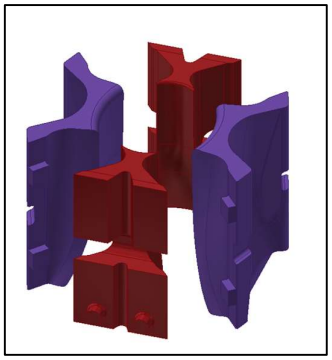
- Dowel for pneumatic heads (see Figure 91);

Figure 91 Dowel for a pneumatic head (Robino & Galandrino)



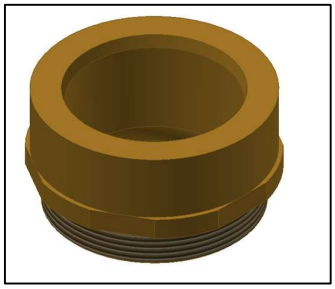
- Dowel for single-stage pneumatic heads (see Figure 92);

Figure 92 Single-stage dowels (Robino & Galandrino)



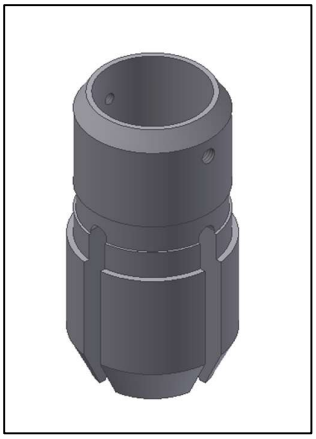
- Centring cone (see Figure 93): this component is always specifically produced, depending on the measures and shapes of the capsule to be centred on the bottle;

Figure 93 Centring cone (Robino & Galandrino)



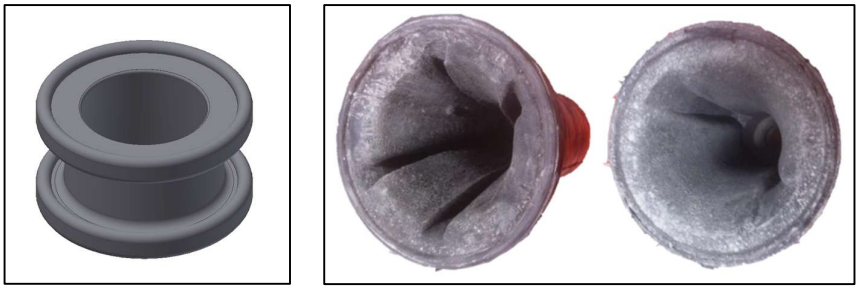
- Distribution bell (see Figure 94), being of different types, depending on dispenser model, capsule specifications and processing kind:
    - With carvings: exploiting material elasticity, it is used for heat-shrinkable capsules;
    - Without carvings, with a check pin under capsule edge: it is used for polylaminate/tin capsules;
    - Without carvings, without pin, with a recording ring on the top: it is used for Spumante large capsules;
    - With a cylinder: it is used for heat-shrinkable pierced capsules;
    - Special ones: they are dedicated and customized, depending on product and machine type;

Figure 94 Distribution bell (Robino & Galandrino)



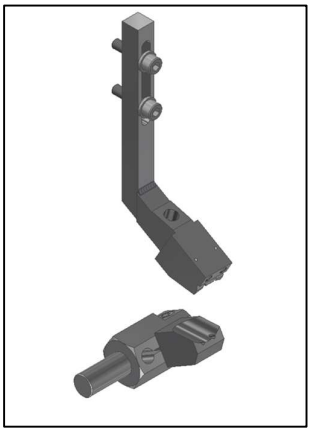
- Spherical caps or shells for bottleneck-shape (see Figure 95);

Figure 95 Spherical caps for bottleneck-shape (Robino & Galandrino)



- Ejection groups or ejectors (see Figure 96), being interchangeable depending on capsule type, are distinguished as follows:
    - For rotative machines, where the heads are mounted on different carousels: it is possible to use some ejector spacers with different measures for folding and straightening operations;
    - For Minibloc and Fenix machines, where the heads are mounted on a single support: it is mandatory for ejector spacers to have the same measure for both processing phases;
    - For 0,187 Lt bottles: dedicated – "special" – ejectors.

Figure 96 Ejectors (Robino & Galandrino)



When facing some peculiar situations, upon customer's request or due to some functional needs, some adjustments can be made to improve any format change or to speed it up. For example, some inserts can be used to regulate belt drawer sides; these components are dedicated and mounted on drawer side shafts, with the aim of speeding up the setting of belt drawer sides, also allowing for it to be precisely managed. However, the need to introduce these parts is an optional one, since it is specifically due to some special exigencies. Thus, these components are not officially introduced as part of the standard procedure to implement a format change *(Robino & Galandrino, 2025).*

5.4.3.1 BOTTLE ANALYSIS TESTS

FIRST ANALYSIS

In the following, the first specified prompt for AI-based bottle dimensional analysis is reported:

"In the following, I will upload some technical drawings of wine/spirit/oil bottles. Starting from the data and from the measures reported in each of these technical drawings, I need you to extract, for each of them: bottle shape (cylindrical, conical, squared); minimum and maximum diameters; height; capacity; intended use (ex: still wine, Spumante wine, oil, whiskey, etc…); cap type (screw, satin, mushroom, etc…). In providing this data, consider the following aspects: a) for cylindrical bottles, I am only interested in the measure of the maximum diameter; b) for conical bottles, I need the measures of both minimum and maximum diameters; c) for squared bottles, I need the measure of the longest side; d) when concerning Spumante wine, also consider the cap in reporting the height value. Include the tolerances when stating these measure values. To make an example of how to approach these drawings, consider that, for the file *Borgognotta AB Deformata cl. 75,* that I have just uploaded, the correct values for the height and for the diameters are the following ones: height 289 ± 1,8; conical shape; minimum diameter 88,2 ± 1,6; maximum diameter 93,4 ± 1,6."

In Figure 97, the results obtained from the first iteration of the first AI-based controls can be found.

CLASSIFICATION	BOTTLE NAME	SHAPE	MAXIMUM DIAMETER (mm)	MINIMUM DIAMETER (mm)	HEIGHT (mm)	CAPACITY (cl)
ATTUALE - in piedi da 12	Renana Breganze collo largo cl.50.pdf	Cylindrical	66.5 ± 1.3	/	337 ±1.9	50
ATTUALE - in piedi da 12	Renana breganze 500 bvs maya.pdf	Cylindrical	66.8 ± 1.3	/	337 ± 1.9	50
ATTUALE - in piedi da 6/12	Bordolese Ecovà BVS cl.75.pdf	Cylindrical	74.5 ± 1.4	/	292 ±1.8	75
ATTUALE - in piedi da 6/12	Bordolese Ecovà TS cl.75.pdf	Cylindrical	74.8 ± 1.4	/	293 ± 1.8	75
ATTUALE - in piedi da 6/12	Bordolese Decò TS cl.75.pdf	Cylindrical	76.3 ± 1.4	/	301 ± 1.8	75
ATTUALE - in piedi da 6/12	Bordolese Nizza cl.75.pdf	Cylindrical	76.4	/	300.5	75
ATTUALE - in piedi da 6/12	Borgognotta Evoluzione bvs.pdf	Cylindrical	80.1 ± 1.5	/	295 ± 1.8	75
ATTUALE - in piedi da 6/12	Borgognotta Eco Evolution TS cl.75.pdf	Cylindrical	80.3 ± 1.5	/	296 ± 1.8	75
ATTUALE - in piedi da 6	Renana Punto TS cl.75.pdf	Conical	80.4 ± 1.5	74.6 ± 1.5	370 ± 2.1	75
ATTUALE - in piedi da 6/12	Champagnotta RDM Ts cl.75.pdf	Cylindrical	80.5 ± 1.5	/	303.1 ± 1.8	75
ATTUALE - in piedi da 6/12	Borgognotta liv.70 mm TS cl.75.pdf	Cylindrical	81.6 ± 1.5	/	296 ±1.8	75
ATTUALE - in piedi da 6/12	Borgognotta tradition bvs cl.75.pdf	Cylindrical	82 ± 1.5	/	295 ± 1.8	75
ATTUALE - in piedi da 12	Seicento Bersano cl.50.pdf	Conical	90.2 ± 1.6	83.2	215 ± 1.5	50
ATTUALE - in piedi da 6/12	Spumante Rosè Asti cl.75.pdf	Cylindrical	87.4 ± 1.5	/	296.2 ± 1.8	75
ATTUALE - coricate da 6/12	Champenoise Modernisè cl.75.pdf	Cylindrical	88.2 ± 1.6	/	300 ± 1.8	75
ATTUALE - in piedi da 6/12	Spumante Euro-Premium cl.75.pdf	Cylindrical	85.7 ± 1.5	/	291 ± 1.8	75
ATTUALE - coricate/in piedi da 6/12	Borgognotta AB Deformata cl.75 definitiva.pdf	Conical	93.4 ± 1.6	88.2 ± 1.6	289 ± 1.8	75
ATTUALE - in piedi da 6	Weinflasche cl.75.pdf	Cylindrical	94.7 ± 1.6	/	289.5 ± 1.8	75
ATTUALE - in piedi da 6	Bordolese Classica 150 cl.pdf	Cylindrical	98 ± 1.7	/	346 ±2	150
ATTUALE - coricate da 6	Borgognotta Prestige 1,5 lt.pdf	Cylindrical	109.7 ± 1.8	/	347 ± 2	150
ATTUALE - coricate/in piedi da 6	Borgognotta AB Deformata cl.150 definitiva.pdf	Conical	112 ± 1.8	109 ± 1.8	365 ± 2.1	150
ATTUALE - in piedi da 6	Champenoise cl.150.pdf	Cylindrical	114.2 ± 1.9	/	371 ± 2.1	150
POTENZIALE - CL.20 NUOVE	8008321 ch se asti 21 alu ag.pdf	Cylindrical	54 ± 1.1	/	210.5 ± 1.4	20
POTENZIALE - CL.20 NUOVE	8036280 prosecchino 63 ag (e bianco).pdf	Cylindrical	55.4 ± 1.2	/	184 ± 1.3	20
POTENZIALE - CL.20 NUOVE	CHAMP. SE 21.pdf	Cylindrical	57.3 ± 1.2	/	188.5 ± 1	20
POTENZIALE	Bordolese TS cl.37,5.pdf	Cylindrical	62.5 ± 1.3	/	241.7 ± 1.6	37.5
POTENZIALE - CL.20 NUOVE	BGT ECOVA T. SUGHERO 37,5 CL.pdf	Cylindrical	65 ± 1.3	/	243 ± 1.6	37.5
POTENZIALE	Borgognotta Ecovà 37,5 vini fermi.pdf	Cylindrical	65 ± 1.3	/	243 ± 1.6	37.5
POTENZIALE - CL.20/37.5 NUOVE	CHAMP. 37,5 CL.pdf	Cylindrical	70.6 ± 1.3	/	243.5 ± 1	37.5
POTENZIALE	Spumante Joelle cl.75 (USA).PDF	Conical	90.6 ± 1.6	87.2 ± 1.6	296.5 ± 1.8	75
POTENZIALE	Collina V1 TC dis. 110385-0988.pdf	Conical	92 ± 1.6	82.8 ± 1.6	287 ± 1.7	75
POTENZIALE	Collio 650 TC_P dis. 180702-0988.pdf	Conical	92.7 ± 1.6	83.5 ± 1.6	287.7 ± 1.8	75

Figure 97 Results from the first iteration of the first bottle AI-based analysis

CAP TYPE	INTENDED USE	NOTES
Satin	Sparkling wine	
BVS screw	Still wine	
BVS screw	Still wine	
Satin	Still wine	It was needed to upload a PNG file containing the technical drawing only for a correct reading ; PDF file was incorrectly read, since the platform did not consider the technical drawing, rather the usage conditions. PNG file was correctly read.
Satin	Sparkling wine	
Satin	Still wine	A PNG screenshot had to be uploaded; with the PDF file height and diameter were incorrectly read. It was needed to specify that tolerances need to be reported only if they are explicitly stated (otherwise they were assumed starting from the ones figuring on the previously uploaded drawings)
BVS screw	Still wine	
Satin	Still wine	A PNG screenshot had to be uploaded; PDF file was incorrectly read. PNG file was correctly read.
Satin	Spumante	It was initially detected as a cylindrical bottle.
Satin	Still wine	
Satin	Still wine	
BVS screw	Sparkling wine	
Satin	Still wine	A tolerance value of 1.6 was initially applied to minimum diameter --> it was needed to specify that tolerances need to be reported only if they are explicitly stated.
Mushroom	Spumante	
Mushroom	Spumante	It initially tended to be detected as a conical bottle.
Mushroom	Spumante	
Satin	Still wine	It was manually provided as an example.
Satin	Still/sparkling wine	
Satin	Still wine	
Satin	Still wine	A PNG screenshot had to be uploaded; PDF file could not be read. It initially detected an incorrect height of 347.2 ± 2 --> then, by highlighting that a mistake was made, it extracted the correct outcome with the second input.
Satin	Still wine	
Mushroom	Spumante	A PNG screenshot had to be uploaded; PDF file could not be read. Moreover, since in the original file the bottle was horizontally positioned, I needed to change drawing orientation to vertically visualize the bottle (otherwise some incorrect data were extracted).
Screw	Spumante	
Screw	Spumante	
Mushroom	Spumante	
Satin	Still wine	
Satin	Still wine	
Satin	Still wine	
Mushroom	Spumante	
Mushroom	Spumante	
Mushroom	Spumante	
Mushroom	Spumante	A PNG screenshot had to be uploaded; PDF file could not be read. It initially detected a wrong diameter of 83.3 ± 1.6 --> then, by highlighting that a mistake was made, it extracted the correct outcome with the second input.

Particularly, this data needs to be interpreted as such:

- Bottle name + measures/shape highlighted in yellow colour: bottle format in relation to which specifications were initially wrongly detected, thus causing a discrepancy with respect to the manually extracted ones (even by uploading the PNG/JPEG file as input, in those cases where the system was not able to read the PDF one);
- Bottle name only highlighted in yellow colour: bottle format whose PDF file could not be read by the platform, thus requiring uploading its technical drawing in PNG/JPEG format, which was then accurately interpreted;
- Bottle name highlighted in purple colour: special bottles, which required the introduction of the condition previously reported as "Special cases" in paragraph 5.4.3.1;
- Data highlighted in green colour: bottle formats whose specifications were straight correctly detected by the system starting from the PDF file, obtaining some results being perfectly aligned with the manually extracted ones.

In Figure 98, the results obtained from the second iteration of the first AI-based controls are reported.

Figure 98 Results from the second iteration of the first bottle AI-based analysis

CLASSIFICATION	BOTTLE NAME	SHAPE	MAXIMUM DIAMETER (mm)	MINIMUM DIAMETER (mm)	HEIGHT (mm)	CAPACITY (cl)	CAP TYPE	INTENDED USE
ATTUALE - in piedi da 12	Renana Breganze collo largo cl.50.pdf	Cylindrical	66.5 ± 1.3	/	337 ±1.9	50	Satin	Sparkling wine
ATTUALE - in piedi da 12	Renana breganze 500 bvs maya.pdf	Cylindrical	66.8 ± 1.3	/	337 ± 1.9	50	BVS screw	Still wine
ATTUALE - in piedi da 6/12	Bordolese Ecovà BVS cl.75.pdf	Cylindrical	74.5 ± 1.4	/	292 ±1.8	75	BVS screw	Still wine
ATTUALE - in piedi da 6/12	Bordolese Ecovà TS cl.75.pdf	Cylindrical	74.8 ± 1.4	/	293 ± 1.8	75	Satin	Still wine
ATTUALE - in piedi da 6/12	Bordolese Decò TS cl.75.pdf	Cylindrical	76.3 ± 1.4	/	301 ± 1.8	75	Satin	Sparkling wine
ATTUALE - in piedi da 6/12	Bordolese Nizza cl.75.pdf	Cylindrical	76.4	/	300.5	75	Satin	Still wine
ATTUALE - in piedi da 6/12	Borgognotta Evoluzione bvs.pdf	Cylindrical	80.1 ± 1.5	/	295 ± 1.8	75	BVS screw	Still wine
ATTUALE - in piedi da 6/12	Borgognotta Eco Evolution TS cl.75.pdf	Cylindrical	80.3 ± 1.5	/	296 ± 1.8	75	Satin	Still wine
ATTUALE - in piedi da 6	Renana Punto TS cl.75.pdf	Conical	80.4 ± 1.5	74.6 ± 1.5	370 ± 2.1	75	Satin	Spumante
ATTUALE - in piedi da 6/12	Champagnotta RDM Ts cl.75.pdf	Cylindrical	80.5 ± 1.5	/	303.1 ± 1.8	75	Satin	Still wine
ATTUALE - in piedi da 6/12	Borgognotta liv.70 mm TS cl.75.pdf	Cylindrical	81.6 ± 1.5	/	296 ±1.8	75	Satin	Still wine
ATTUALE - in piedi da 6/12	Borgognotta tradition bvs cl.75.pdf	Cylindrical	82 ± 1.5	/	295 ± 1.8	75	BVS screw	Sparkling wine
ATTUALE - in piedi da 12	Seicento Bersano cl.50.pdf	Conical	90.2 ± 1.6	83.2	215 ± 1.5	50	Satin	Still wine
ATTUALE - in piedi da 6/12	Spumante Rosè Asti cl.75.pdf	Cylindrical	87.4 ± 1.5	/	296.2 ± 1.8	75	Mushroom	Spumante
ATTUALE - coricate da 6/12	Champenoise Modernisè cl.75.pdf	Cylindrical	88.2 ± 1.6	/	300 ± 1.8	75	Mushroom	Spumante
ATTUALE - in piedi da 6/12	Spumante Euro-Premium cl.75.pdf	Cylindrical	85.7 ± 1.5	/	291 ± 1.8	75	Mushroom	Spumante
ATTUALE - coricate/in piedi da 6/12	Borgognotta AB Deformata cl.75 definitiva.pdf	Conical	93.4 ± 1.6	88.2 ± 1.6	289 ± 1.8	75	Satin	Still wine
ATTUALE - in piedi da 6	Weinflasche cl.75.pdf	Cylindrical	94.7 ± 1.6	/	289.5 ± 1.8	75	Satin	Still/sparkling wine
ATTUALE - in piedi da 6	Bordolese Classica 150 cl.pdf	Cylindrical	98 ± 1.7	/	346 ±2	150	Satin	Still wine
ATTUALE - coricate da 6	Borgognotta Prestige 1,5 lt.pdf	Cylindrical	109.7 ± 1.8	/	347 ± 2	150	Satin	Still wine
ATTUALE - coricate/in piedi da 6	Borgognotta AB Deformata cl.150 definitiva.pdf	Conical	112 ± 1.8	109 ± 1.8	365 ± 2.1	150	Satin	Still wine
ATTUALE - in piedi da 6	Champenoise cl.150.pdf	Cylindrical	114.2 ± 1.9	/	371 ± 2.1	150	Mushroom	Spumante
POTENZIALE - CL.20 NUOVE	8008321 ch se asti 21 alu ag.pdf	Cylindrical	54 ± 1.1	/	210.5 ± 1.4	20	Screw	Spumante
POTENZIALE - CL.20 NUOVE	8036280 prosecchino 63 ag (e bianco).pdf	Cylindrical	55.4 ± 1.2	/	184 ± 1.3	20	Screw	Spumante
POTENZIALE - CL.20 NUOVE	CHAMP. SE 21.pdf	Cylindrical	57.3 ± 1.2	/	188.5 ± 1	20	Mushroom	Spumante
POTENZIALE	Bordolese TS cl.37,5.pdf	Cylindrical	62.5 ± 1.3	/	241.7 ± 1.6	37.5	Satin	Still wine
POTENZIALE - CL.20 NUOVE	BGT ECOVA T. SUGHERO 37,5 CL.pdf	Cylindrical	65 ± 1.3	/	243 ± 1.6	37.5	Satin	Still wine
POTENZIALE	Borgognotta Ecovà 37,5 vini fermi.pdf	Cylindrical	65 ± 1.3	/	243 ± 1.6	37.5	Satin	Still wine
POTENZIALE - CL.20/37.5 NUOVE	CHAMP. 37,5 CL.pdf	Cylindrical	70.6 ± 1.3	/	243.5 ± 1	37.5	Mushroom	Spumante
POTENZIALE	Spumante Joelle cl.75 (USA).PDF	Conical	90.6 ± 1.6	87.2 ± 1.6	296.5 ± 1.8	75	Mushroom	Spumante
POTENZIALE	Collina V1 TC dis. 110385-0988.pdf	Conical	92 ± 1.6	82.8 ± 1.6	287 ± 1.7	75	Mushroom	Spumante
POTENZIALE	Collio 650 TC_P dis. 180702-0988.pdf	Conical	92.7 ± 1.6	83.5 ± 1.6	287.7 ± 1.8	75	Mushroom	Spumante

In the following, the final and definitive prompt for AI-based bottle dimensional analysis.

"In the following, I will upload some technical drawings of wine/spirit/oil bottles. Starting from the data and from the measures reported in each of these technical drawings, I need you to extract, for each of them: bottle shape (cylindrical, conical, squared); minimum and maximum diameters; overall bottle height; capacity; intended use (ex: still wine, Spumante wine, oil, whiskey, etc…); cap type (screw, satin, mushroom, etc…). In providing this data, consider the aspects that are specified in the following. A) In detecting diameter measures and in determining bottle shape, just consider the side quotas, namely the ones external to drawing lines and referred to bottle profile/main body; ignore the internal quotas and the ones characterizing bottle bottom and neck. Anyway, if some ambiguity arises between bottle visual shape and reported quotas, just raise the doubt, rather than unsurely going on, by making some assumptions. B) When a technical drawing shows three diameters, being characterized by a minimal difference among them, one concerning bottle basis and showing the maximum value, another one immediately above it, in the label panel, and showing the minimum value, and a last one related to bottle main body and showing the same value as the maximum one, which then keeps constant, then the bottle needs to be considered as a cylindrical one, thus only the maximum diameter is to be reported. This is due to the fact that the variation between minimum and

maximum diameters is small and limited to bottle basis, specifically to the label panel, while bottle main body keeps constant on maximum diameter's value. C) The bottle is a cylindrical one if, in the drawing, there is just a single side quota external to its body or if the exception explained in point B occurs; otherwise, if there are two quotas and the exception stated in point B does not apply, the bottle is a conical one. D) For cylindrical bottles, I am only interested in the measure of the maximum diameter. E) For conical bottles, I need the measures of both minimum and maximum diameters. F) For squared bottles, I want you to report the measure of the longest side. G) If product type is wine, distinguish between sparkling/still/Spumante. Generally, when you return diameter and height measures, include the tolerances. However, consider this note: insert them in the results only if these ones are explicitly reported in the drawing; on the contrary, if they do not clearly figure, do not suppose them, but simply do not report them in the results, stating that they were not specified. Concerning capacity value, tolerance is not required. Focusing on units of measurement, diameters and heights are to be reported in mm, while capacity needs to be expressed in cl. As long as the files will be uploaded, if these ones contain some multiple documents or both graphics and text, you will need to prioritize bottle technical drawing figuring within the last file sent, which is to be considered as the primary source of analysis; concerning this, you will just need to analyse its specifically inserted data (quotas, measure lines, arrows, tolerances), without taking any other measures or information from any other sources. Every time, analyse the lastly uploaded PDF file and if this one cannot be adequately read, stop and report the issue, asking me to upload the drawing again in PNG/JPEG format. If, even with this other format, the drawing still has a resolution that does not allow you to read measure and/or tolerance digits with absolute certainty (because of them being too little, pixelated or ambiguous), or if data still turns out to be incompatible with some other information contained in the file, do not report any results/values: just generate a clear error message, stating that the uploaded document is not suitable for the analysis and asking me to upload it again. Thus, generally, return some results only if you are totally sure about them; otherwise, if any ambiguity arises, which is such to cause some major doubts, do not make any interpretation or assumption attempts, do not introduce any approximated values, do not make any estimates based on standard models and do not extract any data from any other external sources, but just clearly write that you cannot provide any reliable results and return final judgement to myself."

In the following, in Figure 99, the results of the last iteration of the first AI-based controls are shown.

Figure 99 Results from the last iteration of the first bottle AI-based analysis

CLASSIFICATION	BOTTLE NAME	SHAPE	MAXIMUM DIAMETER (mm)	MINIMUM DIAMETER (mm)	HEIGHT (mm)	CAPACITY (cl)	CAP TYPE	INTENDED USE
ATTUALE - in piedi da 12	Renana Breganze collo largo cl.50.pdf	Cylindrical	66.5 ± 1.3	/	337 ±1.9	50	Satin	Sparkling wine
ATTUALE - in piedi da 12	Renana breganze 500 bvs maya.pdf	Cylindrical	66.8 ± 1.3	/	337 ± 1.9	50	BVS screw	Still wine
ATTUALE - in piedi da 6/12	Bordolese Ecovà BVS cl.75.pdf	Cylindrical	74.5 ± 1.4	/	292 ±1.8	75	BVS screw	Still wine
ATTUALE - in piedi da 6/12	Bordolese Ecovà TS cl.75.pdf	Cylindrical	74.8 ± 1.4	/	293 ± 1.8	75	Satin	Still wine
ATTUALE - in piedi da 6/12	Bordolese Decò TS cl.75.pdf	Cylindrical	76.3 ± 1.4	/	301 ± 1.8	75	Satin	Sparkling wine
ATTUALE - in piedi da 6/12	Bordolese Nizza cl.75.pdf	Cylindrical	76.4	/	300.5	75	Satin	Still wine
ATTUALE - in piedi da 6/12	Borgognotta Evoluzione bvs.pdf	Cylindrical	80.1 ± 1.5	/	295 ± 1.8	75	BVS screw	Still wine
ATTUALE - in piedi da 6/12	Borgognotta Eco Evolution TS cl.75.pdf	Cylindrical	80.3 ± 1.5	/	296 ± 1.8	75	Satin	Still wine
ATTUALE - in piedi da 6	Renana Punto TS cl.75.pdf	Conical	80.4 ± 1.5	74.6 ± 1.5	370 ± 2.1	75	Satin	Spumante
ATTUALE - in piedi da 6/12	Champagnotta RDM Ts cl.75.pdf	Cylindrical	80.5 ± 1.5	/	303.1 ± 1.8	75	Satin	Still wine
ATTUALE - in piedi da 6/12	Borgognotta liv.70 mm TS cl.75.pdf	Cylindrical	81.6 ± 1.5	/	296 ±1.8	75	Satin	Still wine
ATTUALE - in piedi da 6/12	Borgognotta tradition bvs cl.75.pdf	Cylindrical	82 ± 1.5	/	295 ± 1.8	75	BVS screw	Sparkling wine
ATTUALE - in piedi da 12	Seicento Bersano cl.50.pdf	Conical	90.2 ± 1.6	83.2	215 ± 1.5	50	Satin	Still wine
ATTUALE - in piedi da 6/12	Spumante Rosè Asti cl.75.pdf	Cylindrical	87.4 ± 1.5	/	296.2 ± 1.8	75	Mushroom	Spumante
ATTUALE - coricate da 6/12	Champenoise Modernisè cl.75.pdf	Cylindrical	88.2 ± 1.6	/	300 ± 1.8	75	Mushroom	Spumante
ATTUALE - in piedi da 6/12	Spumante Euro-Premium cl.75.pdf	Cylindrical	85.7 ± 1.5	/	291 ± 1.8	75	Mushroom	Spumante
ATTUALE - coricate/in piedi da 6/12	Borgognotta AB Deformata cl.75 definitiva.pdf	Conical	93.4 ± 1.6	88.2 ± 1.6	289 ± 1.8	75	Satin	Still wine
ATTUALE - in piedi da 6	Weinflasche cl.75.pdf	Cylindrical	94.7 ± 1.6	/	289.5 ± 1.8	75	Satin	Still/sparkling wine
ATTUALE - in piedi da 6	Bordolese Classica 150 cl.pdf	Cylindrical	98 ± 1.7	/	346 ±2	150	Satin	Still wine
ATTUALE - coricate da 6	Borgognotta Prestige 1,5 lt.pdf	Cylindrical	109.7 ± 1.8	/	347 ± 2	150	Satin	Still wine
ATTUALE - coricate/in piedi da 6	Borgognotta AB Deformata cl.150 definitiva.pdf	Conical	112 ± 1.8	109 ± 1.8	365 ± 2.1	150	Satin	Still wine
ATTUALE - in piedi da 6	Champenoise cl.150.pdf	Cylindrical	114.2 ± 1.9	/	371 ± 2.1	150	Mushroom	Spumante
POTENZIALE - CL 20 NUOVE	8008321 ch se asti 21 alu ag.pdf	Cylindrical	54 ± 1.1	/	210.5 ± 1.4	20	Screw	Spumante
POTENZIALE - CL 20 NUOVE	8036280 prosecchino 63 ag (e bianco).pdf	Cylindrical	55.4 ± 1.2	/	184 ± 1.3	20	Screw	Spumante
POTENZIALE - CL 20 NUOVE	CHAMP. SE 21.pdf	Cylindrical	57.3 ± 1.2	/	188.5 ± 1	20	Mushroom	Spumante
POTENZIALE	Bordolese TS cl.37,5.pdf	Cylindrical	62.5 ± 1.3	/	241.7 ± 1.6	37.5	Satin	Still wine
POTENZIALE - CL 20 NUOVE	BGT ECOVA T. SUGHERO 37,5 CL.pdf	Cylindrical	65 ± 1.3	/	243 ± 1.6	37.5	Satin	Still wine
POTENZIALE	Borgognotta Ecovà 37,5 vini fermi.pdf	Cylindrical	65 ± 1.3	/	243 ± 1.6	37.5	Satin	Still wine
POTENZIALE - CL 20/37.5 NUOVE	CHAMP. 37,5 CL.pdf	Cylindrical	70.6 ± 1.3	/	243.5 ± 1	37.5	Mushroom	Spumante
POTENZIALE	Spumante Joelle cl.75 (USA).PDF	Conical	90.6 ± 1.6	87.2 ± 1.6	296.5 ± 1.8	75	Mushroom	Spumante
POTENZIALE	Collina V1 TC dis. 110385-0988.pdf	Conical	92 ± 1.6	82.8 ± 1.6	287 ± 1.7	75	Mushroom	Spumante
POTENZIALE	Collio 650 TC P dis. 180702-0988.pdf	Conical	92.7 ± 1.6	83.5 ± 1.6	287.7 ± 1.8	75	Mushroom	Spumante

The prompt which was written to have the AI platform *Google Gemini* determine the necessary change part number and type is here reported:

“Consider the outcomes of the previous analyses and use them to generate a table, depicting all these results and to be exported on Excel. Then, consider the data reported in this specific table, together with the conditions explained in the just uploaded file, concerning sample verification procedure. By analysing the information figuring in the table and the rules described in the file, for each bottle format, determine the necessary change part type, by attributing a progressive letter to it. Consider that different cylindrical bottle formats can share the same change part, upon the conditions stated in the file. On the contrary, when dealing with conical bottles, a dedicated and different change part always needs to be introduced, for each bottle format. Report the results of your analyses in the already mentioned table, by adding a column for change part type and another one for any relevant notes.”

The results obtained from AI usage to determine bottle change part number and type are reported in Figure 100.

Figure 100 AI-based bottle change part determination and pairing for the first analysis

Bottle name	Shape	Capacity (cl)	Max diameter (mm)	Min diameter (mm)	Height (mm)	Gear type	Notes
800321 ch se asti 21 alu ag	Cylindrical	20	54,0 ± 1,1	/	210,5 ± 1,4	A	Diameter range 54,0 - 57,0
8036280 prosecchino 63 ag	Cylindrical	20	55,4 ± 1,2	/	184,0 ± 1,3	A	-
CHAMP. 5E 21	Cylindrical	20	57,3 ± 1,2	/	188,5 ± 1,0	B	Difference > 3mm with respect to the first
Bordolese TS cl.37,5	Cylindrical	37,5	62,5 ± 1,3	/	241,7 ± 1,6	C	Diameter range 62,5 - 65,5
BGT ECOVA T. SUGHERO 37,5	Cylindrical	37,5	65,0 ± 1,3	/	243,0 ± 1,6	C	-
Borgognotta Ecovà 37,5 vini	Cylindrical	37,5	65,0 ± 1,3	/	243,0 ± 1,6	C	-
Renana Bregange collo largo cl.50	Cylindrical	50	66,5 ± 1,3	/	337,0 ± 1,9	D	Diameter range 66,5 - 69,5
Renana bregange 500 bvs mays	Cylindrical	50	66,8 ± 1,3	/	337,0 ± 1,9	D	-
CHAMP. 37,5 CL	Cylindrical	37,5	70,6 ± 1,3	/	243,5 ± 1,0	E	Gear change (discrepancy > 3mm)
Bordolese Ecovà BVS cl.75	Cylindrical	75	74,5 ± 1,4	/	292,0 ± 1,8	F	Diameter range 74,5 - 77,5
Bordolese Ecovà TS cl.75	Cylindrical	75	74,8 ± 1,4	/	293,0 ± 1,8	F	-
Bordolese Decò TS cl.75	Cylindrical	75	76,3 ± 1,4	/	301,0 ± 1,8	F	-
Bordolese Nizza cl.75	Cylindrical	75	76,4	/	300,5	F	No tolerance
Borgognotta Evoluzione bvs	Cylindrical	75	80,1 ± 1,5	/	295,0 ± 1,8	G	Diameter range 80,1 - 83,1
Borgognotta Eco Evolution TS cl.75	Cylindrical	75	80,3 ± 1,5	/	296,0 ± 1,8	G	-
Renana Punto TS cl.75	**Conical**	75	80,4 ± 1,5	74,6 ± 1,5	370,0 ± 2,1	H	**Dedicatad (Conical)**
Champagnotta RDM TS cl.75	Cylindrical	75	80,5 ± 1,5	/	303,1 ± 1,8	G	Inserted in range G for cylindrical bottles
Borgognotta liv.70 mm TS cl.75	Cylindrical	75	81,6 ± 1,5	/	296,0 ± 1,8	G	-
Borgognotta tradition bvs cl.75	Cylindrical	75	82,0 ± 1,5	/	295,0 ± 1,8	G	-
Spumante Rosè Asti cl.75	Cylindrical	75	87,4 ± 1,5	/	296,2 ± 1,8	I	Diameter range 85,7 - 88,7
Champenoise Modernisée cl.75	Cylindrical	75	88,2 ± 1,6	/	300,0 ± 1,8	I	-
Spumante Euro-Premium cl.75	Cylindrical	75	85,7 ± 1,5	/	291,0 ± 1,8	I	-
Seicento Bersano cl.50	**Conical**	50	90,2 ± 1,6	83,2	215,0 ± 1,5	J	**Dedicatad (Conical)**
Spumante Joelle cl.75	**Conical**	75	90,6 ± 1,6	87,2 ± 1,6	296,5 ± 1,8	K	**Dedicatad (Conical)**
Collina V1TC dis. 110385	**Conical**	75	92,0 ± 1,6	82,8 ± 1,6	287,0 ± 1,7	L	**Dedicatad (Conical)**
Collio 650 TC P dis. 180702	**Conical**	75	92,7 ± 1,6	83,5 ± 1,6	287,7 ± 1,8	M	**Dedicatad (Conical)**
Borgognotta AB Deformata cl.75	**Conical**	75	93,4 ± 1,6	88,2 ± 1,6	289,0 ± 1,8	N	**Dedicatad (Conical)**
Weinflasche cl.75	Cylindrical	75	94,7 ± 1,6	/	289,5 ± 1,8	O	Only this cylindrical format
Bordolese Classica 150 cl.	Cylindrical	150	98,0 ± 1,7	/	346,0 ± 2,0	P	Magnum range
Borgognotta Prestige 1,5 lt.	Cylindrical	150	103,7 ± 1,8	/	347,0 ± 2,0	Q	Only this cylindrical format
Borgognotta AB Deformata cl.150	**Conical**	150	112,0 ± 1,8	103,0 ± 1,8	365,0 ± 2,1	R	**Dedicatad (Conical)**
Champenoise cl.150	Cylindrical	150	114,2 ± 1,9	/	371,0 ± 2,1	S	Magnum range

SUBSEQUENT ANALYSES

In the following, in Figures 101 and 102, the results of the second bottle dimensional analysis are reported.

Figure 101 Results from the second bottle AI-based analysis

BOTTLE NAME	SHAPE	MAXIMUM DIAMETER (mm)	MINIMUM DIAMETER (mm)	HEIGHT (mm)	CAPACITY (cl)	CAP TYPE	INTENDED USE	
Brg. Tiffany cc. 750 BB	Cylindrical	81.6 ± 1.50		296 ± 1.8	75	Satin	Still wine	Unreadable PDF; PNG was correctly requested and then read
Borgognotta STD_220342	Cylindrical	80.5 ± 1.5		296 ± 1.8	75	Satin	Still wine	Everything ok
Bordolese Decò DSAR0876	Cylindrical	76.3 ± 1.4		301 ± 1.8	75	Satin	Still wine	Everything ok
BD CLASS TS 375 ML	Cylindrical	63.2 ± 1.3		233 ± 1.6	37.5	Satin	Still wine	Not easily readable PDF; PNG was correctly requested and then read
Bordolese STD 220341	Cylindrical	75.1 ± 1.5		293 ± 1.8	75	Satin	Still wine	Everything ok
PE09806_A_CLASSIC BORDELAISE	Cylindrical	61.3 ± 1.2		260 ± 1.6	37.5	Satin	Still wine	Everything ok
75 CL S BORD.MED	Cylindrical	76.3 ± 1.4		301 ± 1.8	75	Satin	Still wine	Everything ok
Brg.Prestige cc. 1500 BB	Cylindrical	109.7 ± 1.8		347 ± 2	150	Satin	Still wine	Everything ok
Magnum Bordolese	Cylindrical	100 ± 1.7		347 ± 2	150	Satin	Still wine	Everything ok
Bord.Vetri BVS_DSAR	Cylindrical	74.3 ± 1.4		300 ± 1.8	75	Screw	Still wine	Everything ok
BORD.VENETO	Cylindrical	59.8 ± 1.2		260 ± 1.6	37.5	Satin	Still wine	Everything ok

Figure 102 AI-based bottle change part determination and pairing for the second analysis

Bottle name	Max diameter (mm)	Height (mm)	Capacity (cl)	Cap type	Gear type	Technical notes
BORDOLESE VENETO 37.5	59,8 +/- 1,2	260 +/- 1,6	37,5	Satin	A	Ø difference < 2mm; instability needs to be checked because of reduced Ø.
CLASSIC BORDELAISE 37.5CL	61,3 +/- 1,2	260 +/- 1,6	37,5	Satin	A	Ø difference < 2mm; instability needs to be checked because of reduced Ø.
375 cl BD CLASS TS	63,2 +/- 1,3	233 +/- 1,6	37,5	Satin	B	It requires a dedicated gear type (discrepancy > 2mm with respect to A group).
BORD. VETRI 18 75,9-BVS	74,3 +/- 1,4	300 +/- 1,8	75	Screw	C	Standard group for 75cl bottle format; Ø difference internal to the group < 2mm.
75cl BD SICILIA 100% TS	75,1 +/- 1,5	293 +/- 1,8	75	Satin	C	Standard group for 75cl bottle format; Ø difference internal to the group < 2mm.
BORD. DECO' 77-FA	76,3 +/- 1,4	301 +/- 1,8	75	Satin	C	Standard group for 75cl bottle format; Ø difference internal to the group < 2mm.
BORDOLESE MED 750mL R.M.	76,3 +/- 1,4	301 +/- 1,8	75	Satin	C	Standard group for 75cl bottle format; Ø difference internal to the group < 2mm.
75cl BG SICILIA 100% TS	80,5 +/- 1,5	296 +/- 1,8	75	Satin	D	Ø difference < 2mm; optimal grouping.
BORGOGNOTTA TIFFANY 750	81,6 +/- 1,50	296 +/- 1,8	75	Satin	D	Ø difference < 2mm; optimal grouping.
BRD ANTICA ETRUSCA 1500	100 +/- 1,7	347 +/- 2	150	Satin	E	Magnum format; it requires a dedicated gear type.
BORGOGNOTTA PRESTIGE 1500	109,7 +/- 1,8	347 +/- 2	150	Satin	F	Magnum format; it requires a dedicated gear type.

In the following, in Figures 103 and 104, the results of the third bottle dimensional analysis are introduced.

Figure 103 Results from the third bottle AI-based analysis

BOTTLE NAME	SHAPE	MAXIMUM DIAMETER (mm)	MINIMUM DIAMETER (mm)	HEIGHT (mm)	CAPACITY (cl)	CAP TYPE	INTENDED USE	
BD ADRIA *	Cylindrical	82.7 ± 1.5		308.3 ± 1.8	100	BVS screw	Still wine	Poor drawing quality --> since the system could not read the PDF, it correctly requested the PNG, but even this one was imprecisely read (82.1 rather than 82.7 e 309.3 rather than 308.3)
5445_0109	Cylindrical	63.5 ± 1.3		233 ± 1.5	37.5	BVS screw	Sparkling wine	Everything ok
BOTT.T.S BORG.	Cylindrical	104.4 ± 1.7		333 ± 1.9	150	Satin	Still wine	Everything ok
5447_0106	Conical	99.5 ± 1.7	93.7 ± 1.6	346 ± 2	150	BVS screw	Still wine	Everything ok
5880_0106 *	Cylindrical	104.4 ± 1.7		332 ± 1.9	150	BVS screw	Still wine	Poor drawing quality --> since the system could not read the PDF, it correctly requested the PNG, but even this one was imprecisely read (diameter tolerance of 1.1 rather than 1.7)
BOTT.T.V BORG.	Cylindrical	104.4 ± 1.7		332 ± 1.9	150	BVS screw	Still wine	Same bottle format as before but different drawing --> this one is correctly read
Magnum europa	Conical	99.5 ± 1.7	93.7 ± 1.6	346 ± 2	150	Satin	Still wine	Everything ok
5431_0106 Bot	Cylindrical	74.5 ± 1.4		314 ± 1.9	75	BVS screw	Still wine	Everything ok
BORG ROSCATO MAGNUM	Cylindrical	105.6 ± 1.7		332 ± 1.9	150	BVS screw	Sparkling wine	Everything ok
100 CL BD TV28 *	Cylindrical	84 ± 1.5		308 ± 1.8	100	BVS screw	Still wine	Since it could not read the PDF, it correctly requested the PNG, which was correctly read
150 CL BD VERONA *	Cylindrical	98.1 ± 1.7		343.5 ± 2	150	BVS screw	Still wine	Since it could not read the PDF, it correctly requested the PNG, which was correctly read
375 ML BD CLASS	Cylindrical	63.2 ± 1.3		233 ± 1.6	37.5	Satin	Still wine	Everything ok
75 CL BD ALTA	Cylindrical	74 ± 1.4		300 ± 1.8	75	BVS screw	Still wine	Everything ok
RENANA TSV1	Cylindrical	75.2 ± 1.4		330 ± 1.9	75	Satin	Sparkling wine	Everything ok
75 CL BD EXPO *	Cylindrical	74.5 ± 1.4		292 ± 1.8	75	BVS screw	Still wine	Since it could not read the PDF, it correctly requested the PNG, which was correctly read

Figure 104 AI-based bottle change part determination and pairing for the third analysis

Bottle name	Shape	Max diameter (mm)	Capacity (cl)	Gear type	Notes
BORG. TRAD. PESANTE BVS 150	Cylindrical	105.6 +/- 1.7	150	A	Diameter greater than the one for cylindrical 150cl bottle group
BORG. TRADITION L.R. 70 150	Cylindrical	104.4 +/- 1.7	150	A	Difference < 3mm with respect to 105.6; use gear type A
BORG. TRADITION L.R. 60 BVS 150	Cylindrical	104.4 +/- 1.7	150	A	Difference < 3mm with respect to 105.6; use gear type A
MAGNUM EUROPA NEW BIS BVS 150	Conical	99.5 +/- 1.7	150	B	**Conical**: it requires a dedicated gear
MAGNUM EUROPA NEW 150	Conical	99.5 +/- 1.7	150	C	**Conical**: it requires a dedicated gear
150CL BD VERONA BVS	Cylindrical	98.1 +/- 1.7	150	D	Difference > 3mm with respect to 105.6; new gear type D.
100CL BD TV28	Cylindrical	84 +/- 1.5	100	E	Diameter greater than the one for cylindrical 100cl bottle group
100CL BD ADRIA BVS	Cylindrical	82.7 +/- 1.5	100	E	Difference < 3mm with respect to 84; use gear type E
75CL RENANA TSV1	Cylindrical	75.2 +/- 1.4	75	F	Diameter greater than the one for cylindrical 75cl bottle group
BORDOLESE EUR. "550" BVS 75	Cylindrical	74.5 +/- 1.4	75	F	Difference < 3mm with respect to 75.2; use gear type F
75 CL BD EXPO BVS	Cylindrical	74.5 +/- 1.4	75	F	Difference < 3mm with respect to 75.2; use gear type F
75CL BD ALTA LG BVS	Cylindrical	74 +/- 1.4	75	F	Difference < 3mm with respect to 75.2; use gear type F
BORDOLESE CAV BVS 37,5	Cylindrical	63.5 +/- 1.3	37.5	G	Diameter greater than the one for cylindrical 37.5cl bottle group
375ML BD CLASS TSV1	Cylindrical	63.2 +/- 1.3	37.5	G	Difference < 3mm with respect to 63.5; use gear type G

In the following, in Figures 105 and 106, the results of the fourth bottle dimensional analysis are introduced.

BOTTLE NAME	SHAPE	MAXIMUM DIAMETER (mm)	MINIMUM DIAMETER (mm)	HEIGHT (mm)	CAPACITY (cl)
JURA 75 CL *	Conical	85.7 ± 1.5	77.5 ± 1.5	296.2 ± 1.8	75
BG AVANTAGE	Cylindrical	86 ± 1.5		296 ± 1.8	75
MACVIN SPECIAL	Conical	87.6 ± 1.6	78.1	295 ± 1.8	75
CHATEAU CHALON	Conical	89.8 ± 1.6	86.4 ± 1.6	238 ± 1.6	62
MAGNUM JURA 150 CL	Conical	109.4 ± 1.8	98	379 ± 2.1	150
PLAN JURA 37.5 *	Conical	70.5 ±1.3	63	241.5 ± 1.6	37.5
PE03277_B_CHATEAU CHALON *	Conical	89.8 ± 1.6	86.4 ± 1.6	238 ± 1.6	62

Figure 105 Results from the fourth bottle AI-based analysis

CAP TYPE	INTENDED USE	
Satin	Still wine	Since the system could not read the PDF, it correctly requested the PNG. However, drawing quality is poor --> it detects wrong diameters
Satin	Still wine	Everything ok
Satin	Still wine	Drawing quality is very poor--> it detects wrong diameters
Satin	Still wine	Everything ok
Satin	Still wine	Everything ok
Satin	Still wine	Since the system could not read the PDF, it correctly requested the PNG. However, drawing quality is very poor --> it detects cylindrical shape because it incorrectly reads the quotas
Satin	Still wine	Since the system could not read the PDF, it correctly requested the PNG, which was then read correctly

Figure 106 AI-based bottle change part determination and pairing for the fourth analysis

Bottle name	Shape	Max diameter (mm)	Min diameter (mm)	Capacity (cl)	Gear type	Technical notes
75cl JURA	Conical	85,7 ± 1,5	77,5 ± 1,5	75	A	Dedicated gear type (Conical shape)
BG AVANTAGE 77 PLU	Cylindrical	86 ± 1,5	-	75	B	Specific gear type for 86 mm diameter
MACVIN SPECIAL	Conical	87,6 ± 1,6	78,1	75	C	Dedicated gear type (Conical shape)
CHATEAU CHALON	Conical	89,8 ± 1,6	86,4 ± 1,6	62	D	Dedicated gear type (Conical shape)
MAGNUM JURA	Conical	109,4 ± 1,8	98	150	E	Dedicated gear type (Conical shape)
JURA 39	Conical	70,5 ± 1,3	63	37,5	F	Dedicated gear type (Conical shape)

In the following, in Figures 107 and 108, the results of the fifth bottle dimensional analysis are reported.

Figure 107 Results from the fifth bottle AI-based analysis

BOTTLE NAME	SHAPE	MAXIMUM DIAMETER (mm)	MINIMUM DIAMETER (mm)	HEIGHT (mm)	CAPACITY (c	CAP TYPE	INTENDED USE	
SP LIA 700g *	Conical	98.5 ± 1.7	90.4 ± 1.7	252 ± 1.7	75	Mushroom	Spumante	It correctly requested the PNG, but it detected wrong diameters because of drawing poor quality
SILE LIGHT 600g *	Conical	97 ± 1.7	88.9 ± 1.6	243 ± 1.6	75	Mushroom	Spumante	It correctly requested the PNG, but it detected wrong diameters and heights because of drawing poor quality
SP PIAVE LIGHT *	Cylindrica	89.2 ± 1.6	/	270 ± 1.7	75	Mushroom	Spumante	It correctly requested the PNG, that it correctly read
BACCO PESANTE 700 g *	Cylindrica	91.5 ± 1.6	/	279.1 ± 1.8	75	Mushroom	Spumante	It correctly requested the PNG, but it detected wrong diameters and heights because of drawing poor quality
BORD. IMPERIALE BM 600 g	Conical	90 ± 1.6	80 ± 1.5	256 ± 1.6	75	Satin	Still wine	Everything ok
BORDOLESE EXPO - ECOVA	Cylindrica	74.5 ± 1.4	/	232 ± 1.6	75	BVS screw	Still wine	Everything ok
75 cl BD EXPO TS *	Cylindrica	75 ± 1.4	/	233 ± 1.8	75	Satin	Still wine	It correctly requested the PNG, that it correctly read
75 cl BG AUTHENTIQUE	Cylindrica	88 ± 1.6	/	236 ± 1.8	75	Satin	Wine	Everything ok
BORGOGNOTTA CARACTERE	Cylindrica	80.5 ± 1.5	/	236 ± 1.8	75	Satin	Still wine	It correctly requested the PNG, that it correctly read
BORGONOTTA CARACT. ECO	Cylindrica	80.5 ± 1.5	/	235 ± 1.8	75	BVS screw	Still wine	Everything ok
COLLIO BVS *	Conical	92 ± 1.6	84 ± 1.6	284 ± 1.7	75	BVS screw	Sparkling wine	It correctly requested the PNG, that it correctly read
COLLIO LIGHT 620 g *	Conical	92 ± 1.7	81.6 ± 1.7	287 ± 1.8	75	Mushroom	Spumante	It correctly requested the PNG, but it detected wrong diameters and heights because of drawing poor quality
MAGNUM 1,5LT BM *	Cylindrica	118.5 ± 1.9	/	306 ± 1.8	150	Satin	Spumante	It correctly requested the PNG, that it correctly read
MOTIVO BM 750g	Cylindrica	92.2 ± 1.6	/	255 ± 1.6	75	Mushroom	Spumante	Everything ok
PLAY BM 750g *	Cylindrica	93.6 ± 1.7	/	256.4 ± 1.7	75	Satin	Sparkling wine	It correctly requested the PNG, but it detected wrong diameter because of drawing poor quality
MAGNUM 1,5 LT MONTEROSS	Cylindrica	117.3 ± 1.9	/	343 ± 2	150	Mushroom	Spumante	Everything ok
MILLESIMATO BM 0,75 LT 900	Conical	104.3 ± 1.7	93.7 ± 1.6	259 ± 1.6	75	Mushroom	Spumante	Everything ok
FLUTE LIGHT 600g *	Cylindrica	95 ± 1.6	/	302.2 ± 1.8	75	Mushroom	Spumante	It correctly requested the PNG, but it detected conical shape
MAGNUM 1,5lt COLLIO E LEGG	Conical	116.3 ± 1.8	99.5	370 ± 2	150	Mushroom	Spumante	Everything ok
MAGNUM 1,5lt ASTRO 1280g	Conical	127 ± 2	111 ± 1.8	300 ± 1.8	150	Mushroom	Spumante	Everything ok
MOTIVO 20cl	Cylindrica	59.3 ± 1.2	/	175.5 ± 1.3	20	Screw	Spumante	Everything ok
SPUMANTINO 187ml TV 200g *	Cylindrica	55.30 ± 1.2	/	194 ± 1.3	18.7	Screw	Spumante/sparkling win	It correctly requested the PNG, that it correctly read
SPUMANTINO 200 ml TV gr 190	Cylindrica	55.3 ± 1.2	/	194 ± 1.3	20	Screw	Spumante	Everything ok
MAGNUM 1,5lt BM	Conical	131.8 ± 2.1	118.7 ± 1.9	320 ± 1.9	150	Mushroom	Spumante	Everything ok

Figure 108 AI-based bottle change part determination and pairing for the fifth analysis

Gear type	Bottle name	Shape	Maximum diameter (mm)	Notes
A	SPUMANTE LIA TC29	Conical	98.4 ± 1.7	Dedicated (conical bottle)
B	SPUMANTE SILE LIGHT	Conical	97.0 ± 1.7	Dedicated (conical bottle)
C	PIAVE LIGHT 750	Cylindrical	89.20 ± 1.6	3.0 mm difference (maximum limit).
	SPUMANTE MOTIVO 75	Cylindrical	92.2 ± 1.6	
D	SP BACCO PESANTE TC	Cylindrical	91.5 ± 1.6	Dedicated (beyond 3 mm with respect to 88.0 format)
E	BD IMPERIALE B. MOLINO	Conical	90.0 ± 1.6	Dedicated (conical bottle)
F	BD EXPO BVS	Cylindrical	74.5 ± 1.4	0.5 mm difference
	BD EXPO (Raso)	Cylindrical	75.0 ± 1.4	
G	BG AUTH SM	Cylindrical	88.0 ± 1.6	Dedicated (difference > 3 mm with respect to F and C gear types).
H	BG CARAC L+G 63 MM	Cylindrical	80.5 ± 1.5	Same maximum diameter
	BG CARAC L+G BVS	Cylindrical	80.5 ± 1.5	
I	FRIZ. COLLIO BVS	Conical	92.0 ± 1.6	Dedicated (conical bottle)
L	COLLIO LIGHT 7464	Conical	92.0 ± 1.7	Dedicated (conical bottle)
M	MAGNUM BORGOMOLINO	Cylindrical	118.5 ± 1.9	1.2 mm difference
	MAGNUM MONTEROSSA	Cylindrical	117.3 ± 1.9	
N	BTG BORGO MOLINO 750	Cylindrical	93.6 ± 1.7	1.4 mm difference
	SP. FLUTE LIGHT 14	Cylindrical	95.0 ± 1.6	
O	SP. MILLESIMATO CT 75	Conical	104.3 ± 1.7	Dedicated (conical bottle)
P	MAGNUM COLLIO E. LEGG.	Conical	116.3 ± 1.9	Dedicated (conical bottle)
Q	MAGNUM ASTRO LEGGERO	Conical	127.0 ± 2.0	Dedicated. Beyond **120 mm limit**
R	SPUMANTE MOTIVO 20	Cylindrical	59.3 ± 1.2	4 mm max difference (allowed for productions < 5000 b/h)
	BTG SPUMANTE 187	Cylindrical	55.30 ± 1.2	
	SPUMANTINO TV28B	Cylindrical	55.3 ± 1.2	
S	SP. MILLESIMATO 150	Conical	131.8 ± 2.1	Dedicated. Beyond **120 mm limit**

In the following, in Figures 109 and 110, the results of the sixth and last bottle dimensional analysis are shown.

Figure 109 Results from the sixth bottle AI-based analysis

BOTTLE NAME	SHAPE	MAXIMUM DIAMETER (mm)	MINIMUM DIAMETER (mm)	HEIGHT (mm)	CAPACITY (cl)	CAP TYPE	INTENDED USE	
Cin. 20 CL	Cylindrical	54 ± 1.1		210.5 ± 1.4	20	Screw	Spumante	Necessary to straight upload the PNG, because the PDF contains several drawings of different bottle formats
Cin. DE 20 CL	Cylindrical	55.9 ± 1.2		210 ± 1.4	20	Screw	Spumante	Necessary to straight upload the PNG, because the PDF contains several drawings of different bottle formats
DSAR23163	Cylindrical	52.5 ± 1.1		210 ± 1.4	20	Screw	Spumante	Everything ok

Figure 110 AI-based bottle change part determination and pairing for the sixth analysis

BOTTLE NAME	SHAPE	MAX DIAMETER (mm)	CAPACITY (cl)	GEAR TYPE	NOTES
CINZANO ASTI DE 20 CL	Cylindrical	55,9 ± 1,2	20	A	Largest diameter; it defines gear type A
CINZANO 214 CC (AL28)	Cylindrical	54 ± 1,1	21,4	A	Compatible with gear type A (diff. 1,9 mm < 3 mm).
CINZANO 21.4 (AL28)	Cylindrical	52,5 ± 1,1	21,4	B	New gear type: the difference with the 55,9 mm bottle is of 3,4 mm (> 3 mm).

5.4.3.2 CAPSULE ANALYSIS TESTS

FIRST ANALYSIS

The prompt that was initially written to analyse capsule samples is reported in the following lines:

"For each file that I will upload, thus for each capsule format, considering its technical drawing and its specifications, show: lengths; head and base diameters; material; conicity; length/diameter ratio; intended use; colours/finishing; optical centring (none, classical spot, UV spot). Concerning diameters, the head one is always reported, while the base one may not be explicitly shown; whenever this scenario occurs, compute it, considering head diameter, capsule length and its conicity. Focusing on capsule material, if it is necessary, distinguish between head and body ones. In relation to optical centring, if it figures, show the measure of the classical/UV spot. In reporting the requested measures, include the tolerances, if these ones are explicitly introduced; otherwise, just return the nominal value. When dealing with capsule conicity, consider that this one can be expressed in degrees (if the related symbol is clearly shown), in mm or in scale."

In Figure 111, the results of the first iteration of the first AI-based capsule dimensional analysis can be found.

Capsule name	Length (mm)	Head Ø (mm)	Base Ø (mm)	Material (Head/Body)	Conicity	L/D ratio	Intended use
6252E	110 ± 1,5	34	51,28*	Al (38µm) / Poliam. (62µm)	4,5°	3,23	Spumante & Muselet
RETRACPAP PVC	40 ± 1	30,6 ± 0,1	32,90*	Aluminum / PVC	1,15 mm (side)	1,31	Oil
ENOAL POLI 100	115 ± 1	34 ± 1	48,31*	Aluminum / Polylaminate	3° 34'	3,38	Spumante
ELITE ESCVC1767	55 ± 1	29,50 ± 1	31,10*	Polylaminate 200	0° 50'	1,86	Wine
BLANC DE FOC	120 ± 1	34	52,89*	Aluminum / Polylaminate	4° 30'	3,53	Spumante
BLANC PESCADOR	60 ± 1	29 ± 0,1	31,09*	Aluminum / Polylaminate	1°	2,07	Wine
PEÑASCAL ROSADO	60 ± 1	29,25 ± 0,1	30,82*	Aluminum / Polylaminate	0° 45'	2,05	Rosé wine
PONTE VECCHIO	105 ± 1	35 ± 0,25	44,67*	Complex / Complex	2° 38'	3	Spumante / Moscato
COMPLEXPAP 28,2	63 ± 1	28,2	31,07*	Aluminum / Polylaminate	1,30 mm (side)	2,23	Wine
ESTAÑO 29 X 60	60	29	31,09*	Tin / Tin	1°	2,07	Wine
COMPLEXPAP 29,2	60 ± 1	29,25 ± 0,1	30,27*	Aluminum / Polylaminate	0,51 mm (side)	2,05	Wine
KAVAKLIDERE	120 ± 1	34,5 ± 1	45,37	Aluminum / Polylaminate	~ 5,17°	3,48	Wine / Spumante
6228C	122 ± 1,5	34	53,20*	Al (38µm) / Poliam. (62µm)	4,5°	3,59	Spumante & Muselet

Figure 111 Results from the first iteration of the first capsule AI-based analysis

Colours / Finishing	Optical centring	
Metallic PMS8400C/PMS8404C Matt, Black (Hot Foil and Gloss), Black	UV (30x6 mm)	
Black Matt / Golden	Classic spot (5 mm)	Conicity tolerance is missing. The spot needs to be reported only if it is explicitly specified on the drawing.
Black / Golden and White Matt	Spot (5x7 mm)	
Grey / Embossed logo	None	
Golden	Classic spot	The colour cannot be determined on a visual basis: it needs to be reported only if it is explicitly specified on the drawing. Conicity tolerance is missing. The spot needs to be reported only if it is explicitly specified on the drawing.
Green / Dec. Sea	None	The colour cannot be determined on a visual basis: it needs to be reported only if it is explicitly specified on the drawing. Conicity tolerance is missing.
Grey / White	None	The colour cannot be determined on a visual basis: it needs to be reported only if it is explicitly specified on the drawing. Conicity tolerance is missing.
Grey	Classic spot (5 mm)	The colour cannot be determined on a visual basis: it needs to be reported only if it is explicitly specified on the drawing. Conicity tolerance is missing. The spot needs to be reported only if it is explicitly specified on the drawing.
White / Green / Silver	Classic spot	The spot needs to be reported only if it is explicitly specified on the drawing. Conicity is expressed in mm, so the trigonometric formula cannot be applied.
Silver / Black	None	
Silver Matt / Rose	None	Conicity tolerance is missing.
Platinum / Golden Gloss	Classic spot (2 mm)	It converted the conicity expressed in scale in a conicity expressed in degrees. The spot needs to be reported only if it is explicitly specified on the drawing.
Black Matt / Golden Foil	UV (4x75 mm)	

In the following, the refined and optimized prompt for AI-based capsule dimensional analysis is reported:

"For each file that I will upload, thus for each capsule format, considering its technical drawing and its specifications, and prioritizing the technical drawing, show: lengths; head and base diameters; any potential diameters, being either smaller or larger than the head and base ones (ex: head pad diameter, engraving diameter, etc…); material; conicity; length/diameter ratio; intended use (product type where the capsule will be used); colours/finishing; optical centring, if present (none, classical spot, UV spot). Consider the rules that are specified in the following. A) Concerning diameters, the head one is always reported within the file, while the base one may not be explicitly shown. Therefore, if base diameter is explicitly included among capsule specifications, return the reported value; on the contrary, if base diameter is not shown, compute it, by using the most appropriate formula. For all base diameters that you personally computed, because of them not being explicitly expressed in the technical drawing, add an * next to the numerical value. B) Focusing on capsule material, if it is necessary, distinguish between head and body ones. C) In relation to optical centring, fill in the related field only if there is a clear indication in the file, concerning its presence/absence; on the other hand, if no information figures relative to optical centring, do not make any visual assumption, but simply

point out that there is no available data concerning this specific aspect. Moreover, in case the optical centring is present, it is necessary that you also return its measure. However, consider this aspect: this figure needs to be included among the results only if it is explicitly shown in the drawing; on the contrary, if the spot is reported, but there is no clear information about its dimensions, do not assume them, but simply only return the spot type, without any measures. D) In reporting capsule length, diameters and conicity, include the tolerances, but only if these ones are explicitly introduced; otherwise, just return the nominal value. E) When dealing with capsule conicity, consider that this one can be expressed in degrees (if the related symbol is clearly shown), in mm or in scale. Depending on how it is stated in the drawing, when you compute base diameter, pay attention to use the kind of formula that reveals to be the most appropriate one for the way in which conicity is reported. F) Capsule colour cannot ever be assumed or derived on a visual basis. Therefore, include it in the results only if it is explicitly written among capsule specifications; on the contrary, if there is no clear and explicit indication about it, just leave this field empty. G) Concerning capsule head diameter, conicity and total height, if these measures do not explicitly figure in the drawing in the form of quotas, try to consider the field named "Measurements": it may show these dimensions, if it is present."

In Figure 112, the results obtained from the second and last iteration of the first AI-based capsule analysis can be found.

Capsule name	Length (mm)	Head Ø (mm)	Base Ø (mm)	Other relevant Ø (mm)	Material (Head/Body)	Conicity
6252E	110 ± 1,5	34	51,31*	Head disk: 38; Max printing area on disk: 22	Al (38µm) / Polylam. (62µm)	4,5°
RETRACPAP PVC (4606)	40 ± 1	30,6 ± 0,1	32,90*	Head pad: 23 + 0,1	Aluminum / PVC	1,15 mm + 0,1
ENOAL POLI 100 (2021/200)	115 ± 1	34 ± 1	48,34*		Aluminum / Polylaminate	3° 34'
ELITE ESCVC1767 (2020/317)	55 ± 1	29,50 ± 1	31,1*		Polylaminate 200	0° 50'
BLANC DE FOC (0080090)	120 ± 1	34	52,9*	Head pad: 28	Aluminum / Complex polylaminate	4° 30' ± 5'
BLANC PESCADOR (080090/57)	60 ± 1	29 ± 0,1	31,1*	Rebaje: 28,5 ± 0,25; Smooth ring: 31,89 ± 0,2	Aluminum / Complex polylaminate	1° ± 5'
PEÑASCAL ROSADO (470054/118)	60 ± 1	29,25 ± 0,1	30,82*	Rebaje: 28, 75 ± 0,25; Smooth ring: 31,49 ± 0,2	Aluminum / Complex polylaminate	0° 45' ± 5'
PONTE VECCHIO (470054/7)	105 ± 1	35 ± 0,25	44,67*		Complex / Complex	2° 38' ± 5'
COMPLEXPAP 28,2 (8321/1)	63 ± 1	28,2	30,8*		Complex polylaminate	1,30 mm
ESTAÑO 29 X 60 (240055)	60	29	31,1*		Tin	1°
COMPLEXPAP 29,2 (5283)	60 ± 1	29,25 ± 0,1	30,27*	Opening: 28, 25 ± 0,1; Head pad: 30 + 0,1	Aluminum / Polylaminate	0,51 mm ± 0,1
KAVAKLIDERE (5544/19)	120 ± 1	34,5 ± 1	45,37 ± 1	Head engraving: 18 ± 1	Aluminum / DERMA 75	01:10,5
6228C	122 ± 1,5	34	53,22*	Head disk: 38; Max printing area on disk: 22	Al (38µm) / Polylam. (62µm)	4,5°

Figure 112 Results from the second iteration of the first capsule AI-based analysis

L/D ratio	Intended use	Colours / Finishing	Optical centring
3,23	Spumante & Muselet	Metallic PMS8400C/PMS8404C Matt, Black (Hot Foil and Gloss), Black	UV (30x6 mm)
1,31	Oil	Black Matt / Golden	Not available data
3,38	Spumante	Black / Golden and White Matt	Classic spot (5x7 mm)
1,86	Wine	Grey / Embossed logo	Nessuno
3,53	Spumante	Not available data	Not available data
2,07	Wine	Not available data	Not available data
2,05	Rosé wine	Not available data	Not available data
3	Spumante / Moscato	Not available data	Not available data
2,23	Wine	White / Green / Silver	Not available data
2,07	Wine	Silver / Black / Embossing inked in silver colour	Not available data
2,05	Wine	Silver Matt / Rose	Not available data
3,48	Wine / Spumante	Platinum / Golden Gloss / G07 Moet embossing	Not available data
3,59	Spumante & Muselet	Black Matt / Golden Gloss - Hot Foil / Black Gloss	UV (75 x 4 mm)

In the following, the prompt that was written to have the AI platform *Google Gemini* determine the necessary capsule change part number and type is reported:

"Starting from the results obtained for each capsule format, generate a table, to be exported on Excel and containing all analysis outcomes. In doing this, include the tolerance related to capsule conicity (if present) and any potential diameters being either greater or smaller than the head and base ones. Then, by using this table and the PDF file concerning sample verification procedure, that I have just uploaded, determine the necessary change part type for each capsule format, assigning to it a progressive letter. In doing so, use the indications and the rules that are explained in the file, which need to be specifically adapted to the results reported in the table generated starting from previous analysis results. Once capsule change parts will have been determined, generate a second table including them, to be again exported on Excel; also include any technical notes, showing any peculiar aspects which need to be considered in choosing capsule change part type and number."

The results obtained from AI usage to determine capsule change part number and type are reported in Figure 113.

Figure 113 AI-based capsule change part determination and pairing for the first analysis

Gear type	Paired formats	Bell type	Technical notes
A	6252E, 6228C	Spumante (No carvings)	Formats grouped for length > 90mm; variation < 5mm is accepted
B	4606	Heat-shrinkable (No carvings)	L/D ratio < 1,5: point out possible distribution criticality to the CO
C	2021/200, 0080090	Spumante (No carvings)	Same head (Ø34). Allowed length variation: 5mm
D	2020/317	Polylaminate (No carvings)	Reduced conicity: it requires a dedicated bell with pin
E	080090/57, 240055	Tin/Polylaminate (No carvings)	For tin (240055) length tolerance = 0 mm
F	470054/118, 5283	Polylaminate (No carvings)	Same head diameter (29,25). Compatible conicity
G	470054/7, 5544/19	Spumante (No carvings)	Long length; verify centring spot positioning
H	8321/1	Complexpap (No carvings)	Reduced head Ø (< 27 mm); verify storage compatibility

SUBSEQUENT ANALYSIS

In Figure 114, the results of the second AI-based capsule dimensional analysis can be found.

Capsule name	Length (mm)	Head Ø (mm)	Base Ø (mm)	Other relevant Ø (mm)	Material (Head/Body)	Conicity	L/D ratio	Intended use	Colours/Finishing	Optical centring
OVERCAP GRAPHIC EXAMPLE	145 ± 1	34 ± 1	51,16 ± 1	/	Enoal / Derma 65	01:08	4,26	Spumante	Custom Pink, Silver Gloss, Embossed finishing (dots)	Spot (8x10)
OVERCAP TD	145	34	51,16	Head pad: 22	Enoal	01:08	4,26	No data	No data	No data
SPW_CAPSULA1	15,5 ± 0,30	28,6 ± 0,35	28 ± 0,35 (inner)	Push-entrance: 26,2	Aluminum	Not explicitly stated	0,54	No data	No data	No data
SPW_CAPSULA2	23 ± 0,35	31,4 ± 0,35	29,2 ± 0,35	Inner: 27,4 ± 0,35	Polyethylene HD	Not explicitly stated	0,73	Over-capsule	No data	No data
SPW_CAPSULONE1	92	33	41,21	Head pad: 22	Enoal/Derma 75 (complex multi-layered)	01:10,5	2,79	Spumante	No data	No data
SPW_CAPSULONE2	95 ± 1	33 ± 1	41,50 ± 1	/	Aluminum (Enoal) / Derma 65 (complex multi-layered)	01:10,5	2,86	Spumante	Custom Pink, Silver Gloss, Embossed finishing (dots)	Spot (5x8)

Figure 114 Results from the second capsule AI-based analysis

Everything ok
Everything ok
It was necessary to upload a PNG of the capsule format alone, because the PDF file containing it also reported other drawings of other capsule formats (the system did not undestand which one to consider)
It was necessary to upload a PNG of the capsule format alone, because the PDF file containing it also reported other drawings of other capsule formats (the system did not undestand which one to consider). Base diameter is not accurately reported. it is not easy to understand which one is to be considered
It was necessary to upload a PNG of the capsule format alone, because the PDF file containing it also reported other drawings of other capsule formats (the system did not undestand which one to consider)
It was necessary to upload a PNG of the capsule format alone, because the PDF file containing it also reported other drawings of other capsule formats (the system did not undestand which one to consider)

In Figure 115, the results obtained from AI usage to determine capsule change part number and type for the second analysis are reported.

Figure 115 AI-based capsule change part determination and pairing for the second analysis

Gear type	Paired formats	Bell type	Technical notes
A	EN004917, EN004918	Spumante (Without carvings)	**Critical L/D ratio (4,26)**: very high, it requires stability check. These formats share diameter and conicity, but EN004917 is an optical one (it requires optical centring)
B	PP 28x16	Polylaminate/Aluminum	**L/D < 1,5 (0,54)**: risk of distribution problems; point this out to CO to inform the customer
C	Over-capsule ø28	Special (Plastic)	Diameter < 35 mm. Rigid material, it requires a deicated bell for diameter ø 31,5
D	Cod. 5275, EN004919	Spumante (Without carvings)	Possible grouping: length difference of 3 mm (92 vs 95), acceptable for L > 90 mm. Same head diameters (33 mm)

5.4.3.3 WIRE-HOOD ANALYSIS TESTS

FIRST ANALYSIS

In the following, the prompt that was written to have the AI platform analyse wire-hood technical drawings is reported:

“In the following, I will upload some wire-hood technical drawings. For each of these files, thus for each wire-hood format, considering the specifications figuring in the drawing, return: wire-hood total height; head diameter; diameter of the area under the ligation hook; material. Where it is possible, include wire diameter, its breaking strength and belt developed length; on the contrary, if this data does not explicitly figure, leave this field empty, specifying that this information was not available. If tolerances are explicitly reported, include them while detecting any measures; otherwise, if they are not clearly stated, just return the nominal value. Furthermore, when dealing with wire-hoods having a muselet cap, consider that the head diameter corresponds to the diameter of the muselet cap itself.”

In Figure 116, the results of the first AI-based wire-hood dimensional analysis are reported.

Figure 116 Results from the first wire-hood AI-based analysis

Wire-hood name	Total height (mm)	Head Ø (mm)	Under-ligation-hook Ø (mm)	Material	Wire Ø (mm)	Resistance (N/mm2)	Belt development (mm)
Generico (Scheda 1)	38.4 +/- 0.9	29.7 +/- 0.6	44 +/- 0.9	Steel / Tinned stripe	1.00 +/- 0.02	320 - 450	155 +/- 1
DP H 36	36.3 +/- 0.9	28.5 +/- 0.5	42.8 +/- 0.9	Steel / Tinned stripe	1.00 +/- 0.02	320 - 450	149.5 +/- 1
DEM BTL MAG MI MC	38.3 +/- 0.9	29.7 +/- 0.6	44 +/- 0.9	Steel / Tinned stripe	1.00 +/- 0.02	320 - 450	155 +/- 1
MC MCIII	38.2 +/- 0.8	29.8 +/- 0.5	43.8 +/- 0.6	Steel / Tinned stripe	1.00 +/- 0.02	320 - 450	No available data
RU CHAMPAGNE	36.3 +/- 0.9	28.5 +/- 0.5	42.8 +/- 0.9	Steel / Tinned stripe	1.00 +/- 0.02	320 - 450	149.5 +/- 1
DC	36.1 +/- 0.9	29.7 +/- 0.6	44 +/- 0.9	Steel / Tinned stripe	1.00 +/- 0.02	320 - 450	155 +/- 1

In the following, the prompt that was provided to have the AI platform determine wire-hood change part number and type is reported:

"Starting from the results obtained for each wire-hood format, generate a table, to be exported on Excel. Then, considering the data reported in this table and the file concerning order validation procedure, that I have just uploaded, determine the most appropriate wire-hood change part type to be paired with each format, assigning a progressive letter to it. Consider that different wire-hoods can share the same change part type, according to the rules and conditions explained in the file. Add the information concerning change part number and type in the previously mentioned table."

In Figure 117, the results obtained from AI usage to determine wire-hood change part number and type are shown.

Figure 117 AI-based wire-hood change part determination and pairing for the first analysis

Wire-hood name	Wire-hood type	Muselet cap diameter (mm)	Gear type (Head/Belt)
Gabbietta 1 (Standard)	Free belt with muselet cap	29,7	A
MC	Free belt with muselet cap	29,7	A
V - MCIII	Free belt with muselet cap	29,8	A
DC	Free belt with muselet cap	29,7	A
DP H 36	Free belt with muselet cap	28,5	B
RC	Free belt with muselet cap	28,5	B

SUBSEQUENT ANALYSIS

In Figure 118, the results of the second AI-based wire-hood dimensional analysis are reported.

Figure 118 Results from the second wire-hood AI-based analysis

Wire-hood name/type	Total height (mm)	Head diameter (mm)	Under-ligation-hook diameter (mm)	Material	Wire diameter (mm)	Breaking strength	Developed belt length
Gabbietta Cintura Libera	32	25	42,5	AL.51	0,95 ± 0,20	No available data	No available data
Torretta Vittoria Junior	37	26	42	AL.51	0,95 ± 0,20	No available data	No available data
Torretta C	36,5	26 ÷ 26,5	42	AL.51	0,95 ± 0,20	No available data	No available data
Gabbietta x Bot 250 cl	36,5 ÷ 37	26,3	41,5 ÷ 42	AL.51	0,95 ± 0,20	No available data	No available data
CA	36,5	26 ÷ 26,5	42	AL.51	0,95 ± 0,20	No available data	No available data
Torretta Vittoria x Eurostar	36,5	26 ÷ 26,5	41,5	AL.51	0,95 ± 0,20	No available data	No available data

In Figure 119, the results obtained from AI usage to determine wire-hood change part number and type are shown.

Figure 119 AI-based wire-hood change part determination and pairing for the second analysis

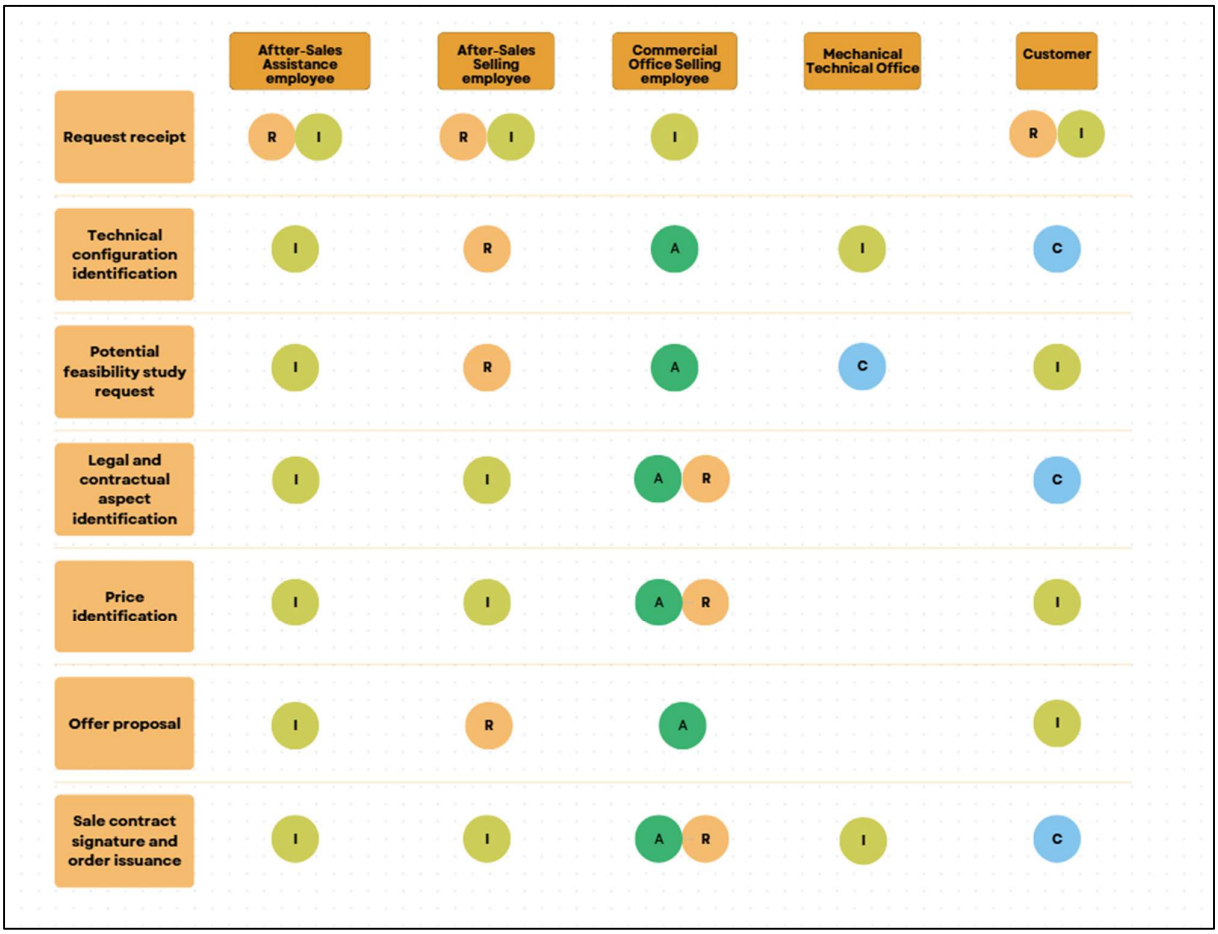
Pagina	Wire-hood name/type	Under-ligation-hook Ø(mm)	Head/Muselet cap Ø (mm)	Belt Ø (Nominal)	Gear type
1	Gabbietta Cintura Libera	42,5	25	42,5	A
2	Torretta Vittoria Junior	42	26	42	B
3	Monobl. Vittoria T1/1 (Gerval)	42	26,5	42	B
4	Torretta Carlsberg	42	26 ÷ 26,5	42	B
5	Gabbietta x Bot 250 cl	41,5 ÷ 42	26,3	41,75*	B
6	Torretta Vittoria x Cime	41,5	26	41,5	B
7	Celliers Associés	42	26 ÷ 26,5	42	B
8	Torretta Vittoria x Eurostar	41,5	26 ÷ 26,5	41,5	B

6. STRATEGIC IMPORTANCE OF AFTER SALES DEPARTMENT

6.1.4 *RACI* MATRIX

In the following, in Figure 120, the *RACI* matrix is reported.

Figure 120 RACI Matrix



BIBLIOGRAPHY

Considering that this thesis emerged from the need of formalizing change part engineering and production process, since this was not structured and organized into a comprehensive documentation, it needs to be clarified that a relevant part of the information which this thesis' content is based on comes from oral sources collected from men and women working within the company.

REFERENCES TO PUBLIC DOCUMENTS

Grant R.M., Contemporary Strategic Analysis, John Wiley & Sons Inc, 11th edition, November 2021

Alberto De Marco, Project management for facility constructions, Springer, 2nd Edition, 2018

Fulvio Lavina & Giuseppe Billella, Something from nothing: the emergence of Canelli's oenological industry, Fabiano Editore, October 2024

Curry G.L. & Feldman R.M., Manufacturing Systems Modeling and Analysis, Springer, 2011

Franceschini Fiorenzo, Advanced Quality Function Deployment, St. Lucie Press/CRC Press, 2001

Curry G.L. & Feldman R.M., Manufacturing Systems Modeling and Analysis, Springer, 2011

Simeone A., Adaptive Assistance, AI and Social Value, Politecnico di Torino

Simeone A., Human-Centred Mnaufacturing, Cognitive Load and Inclusion, Politecnico di Torino

Besanko & Braeutigam, Microeconomics, Wiley, 4th edition, 2011

R. Stark, G. Seliger & J. Bonvoisin, Sustainable Manufacturing Challenges, Solutions and Implementation Perspectives, Springer, 2017

WEBSITE REFERENCES

Enrico Rudello, Digital Marketing – Porter's Diamond: what it is and how to use it to expand your business, Ruèn

SAP, Procurement vs purchasing: know the differences, July 2024

Robino & Galandrino S.p.A, Website

Google Gemini

Basler, Deep Learning Vision Systems for Industrial Image Processing, December 2025

Pekat Vision, Machine Vision in Quality Inspection: Traditional vs. Deep Learning Approaches, July 2024

QRP, RACI Matrix: what it is and why it is important, March 2024

Salesforce, What are the 4 types of CRM?

Amanda McGrath & Amanda Downie, What is CRM automation, IBM

Jens Ackermann, What is After Sales Service, Claimlane, June 2026

INTERNAL COMPANY DOCUMENTS

Robino & Galandrino S.p.A., Piano di Sviluppo – Allegato n.8, Progetto Industrial CApping Machine Excellence – IN.CA.M Excellence, November 2021

Robino & Galandrino S.p.A., Piano di Sviluppo – Allegato n.18: Rapporto Tecnico, Progetto Industrial CApping Machine Excellence – IN.CA.M Excellence, November 2021

Robino & Galandrino S.p.A, The capsuling process

Robino & Galandrino S.p.A, Sample verification procedure, 2025

Robino & Galandrino S.p.A, Alphacam Quote

Robino & Galandrino, Various unofficially stored documents

RINGRAZIAMENTI

Il più delle volte chiamiamo buio la luce che i nostri occhi non riescono a vedere.

Fëdor Dostoevskij

A mamma e papà: l'amore e la fiducia che mi avete sempre riservato non hanno mai conosciuto limiti, anzi si sono stretti in un abbraccio ancora più forte e caldo nei tratti più impervi di questo percorso. Grazie per avermi lasciata libera di sognare, credere, provare e sbagliare. Grazie per avermi sempre riconosciuto la fatica e lo sforzo che hanno fatto da motore ad ogni mia decisione, senza mai dubitare dell'impegno costante che ha guidato ogni mio passo. Grazie per non aver mai infierito contro i miei sbagli e le mie debolezze, incoraggiandomi, al contrario, a riprovare sempre, pensando a ciò che ho a mano a mano raggiunto e mai a quello che è andato perso. Grazie per essere sempre stati attenti ai miei bisogni ed alle mie esigenze e per avermi fatto dono di valori saldi e certi, di cui ho fatto tesoro nei momenti in cui mi sono sentita persa.

A John: è difficile ingabbiare in qualche riga il sentimento che ci unisce, eppure penso che tra le pagine di un libro si celi una frase che riesce a farlo al meglio. "Laddove lei era tutta spigoli, lui possedeva anse per accoglierli: lui era la luce che addolciva le sue ombre". Solo io e te sappiamo quanti spigoli del mio essere ti ho dato modo di scovare in questi anni; la precarietà e l'incertezza del futuro che mi attende, unite ad una consapevolezza non sempre così salda delle decisioni che mi hanno portata a scegliere questo percorso, mi hanno fatta vacillare spesso, lasciandomi in preda ai dubbi ed alle angosce dell'ignoto, che io tanto temo. È in questi momenti che ho capito la portata del tuo amore e la profondità del tuo animo sensibile e sempre aperto all'altro, che non si è mai fatto intimorire dai miei momenti di esasperazione, ma che, al contrario, li ha sempre accolti con pazienza e fiducia. Sei stato capace di leggere tra le righe dei miei momenti "no", riscoprendo ogni giorno le ragioni per cui ci siamo scelti ed accogliendomi ogni sera tra le due salde e dolci braccia, che hanno attutito gli urti delle giornate più difficili, infondendomi sempre la forza e la fiducia di cui avevo più bisogno.

A Gloria: nonostante tu sia la persona con cui mi sono probabilmente scontrata di più in assoluto, di una cosa sono certa, ovvero che nessun litigio e nessuna incomprensione potranno mai avere la meglio sul profondo legame che ci unisce. Anzi, le nostre innumerevoli sfuriate sono sintomo di un rapporto davvero genuino e sincero, caratterizzato da scambi sempre diretti e schietti, che ci hanno dato modo di conoscerci a fondo, realizzando una consapevolezza totale delle numerose sfumature che ci portiamo dentro, che abbiamo poi sempre accettato, abbracciato e custodito. Sei per me la sorella che non ho mai avuto, una persona a cui posso confidare qualsiasi pensiero, con cui posso davvero essere me stessa in ogni mia sfaccettatura. Rappresenti per me un punto di riferimento costante, una presenza certa che mai resterà sorda di fronte alle mie richieste, sempre disposta a sorbirsi le mie preoccupazioni ed a liberarsi di qualsiasi impedimento nel momento del bisogno. Sono certa che saremo sempre capaci di fare tesoro dell'affetto sincero che ci unisce, custodendolo con cura e difendendolo da ogni colpo, consapevoli che costituiamo l'una per l'altra una risorsa rara e preziosa, custode di un'amicizia che trae forza dalle nostre diversità, capace di sopperire alle nostre rispettive mancanze per alimentare un legame saldo e unito, che nulla può realmente spezzare.

A Lollo: i momenti che abbiamo vissuto insieme dentro e fuori le mura del glorioso Istituto Da Vinci sono stati così potenti e determinanti che mi hanno portata a scoprire in te il fratello che non ho, per cui sarei disposta ad affrontare ogni sfida, pur di difendere e tenere alta l'unicità del rapporto che ci lega. Sei la nota di colore della nostra piccola famiglia elettiva: la tua battuta è sempre pronta per distendere anche le atmosfere più tese e la tua presenza è fondamentale per portare il sereno nelle giornate più grigie. Conservo tra i miei doni più preziosi i ricordi degli anni che abbiamo condiviso insieme, perché ogni momento trascorso in compagnia del nostro gruppo ha arricchito il mio cuore di emozioni indelebili, perché la sola prospettiva di passare una serata in compagnia, giocando a Trivial davanti al caminetto di Valpone, è stata ed è abbastanza per sentirmi sollevata da ogni brutto pensiero.

A Giovanni: se Lollo rappresenta lo scoppiettante fuoco d'artificio della nostra compagnia, tu sei invece l'ombra riservata, cauta, un po'misteriosa e non sempre decifrabile, che però mai si allontana. Il rapporto che ci lega si è snodato ed evoluto su tratti impervi e sicuramente tortuosi, costellati di incomprensioni e scontri che non ci siamo mai risparmiati, ma ha tratto progressiva forza da un affetto sincero, che mai ci siamo espressi a parole, ma che sempre abbiamo rinnovato nella scelta di continuare ad investire in un'amicizia vera. In certi momenti, le divergenze e le diversità che da sempre ci caratterizzano avrebbero potuto avere la meglio, ma, negli anni, abbiamo imparato a venirci incontro, a perdonarci i nostri rispettivi limiti ed a comprendere meglio le nostre visioni. Qualche tempo fa, avrei avuto bisogno di parole certe e schiette per riconoscere in te quell'affetto che noi altri dimostriamo così apertamente; ora, invece, ho imparato a decifrare le tue ombre, a leggere tra le righe dei tuoi non detto, a riconoscere chiaramente nei tuoi piccoli e grandi gesti l'intensità e la forza affettiva di un legame di cui non ho mai più dubitato.

A Marzia: in questi anni, sei diventata per me un'amica davvero speciale, con cui ho condiviso discorsi seri e profondi, ma anche tante risate spensierate e momenti un po' scemi. Ogni anno, le vacanze a San Lozzo sono diventate il motore per dare la carica necessaria a ripartire a settembre ed i viaggi con te in pullman hanno alleggerito anche le giornate più stancanti. Sei la mia stella super brillante, sempre disponibile ad accettare ogni proposta di qualche ora trascorsa in compagnia, così che la più banale delle passeggiate o la più semplice delle cene possa trasformarsi in un'opportunità per staccare la spina ed rallegrarsi a vicenda.

A Chiaretta ed Elisa: grazie per tutti i momenti di svago che abbiamo condiviso insieme, perché tra una serata passata a giocare a qualche gioco in scatola e qualche festa di paese, tra le tradizioni natalizie e qualche viaggetto insieme, questi anni sono volati, donandomi quella spensieratezza e quel piacere di stare insieme che hanno dato la carica a questa lunga avventura.

A Ilaria: alla mia compagna dell'asilo, poi diventata per un anno mia coinquilina, un grande grazie per essere riuscite a preservare la nostra amicizia per tutti questi anni. Grazie per ogni spesa ed ogni cucinata condivisa a Torino, grazie per le Pasquette, i Ferragosti ed i Capodanni insieme e, soprattutto, grazie per il tuo spirito di iniziativa e per la tua inclusività, che ti porta sempre a cercare di allargare il gruppo il più possibile e che mi ha permesso di incontrare in questi anni altre persone speciali, con cui abbiamo condiviso serate piacevoli e giornate spensierate.

A Laura: abbiamo percorso insieme i primi step di questa avventura universitaria, iniziata con una spontanea proposta di un caffè dopo lezione e poi arricchitasi e rafforzatasi durante l'anno ad Athlone, in cui, da affiatate coinquiline, abbiamo condiviso merende-studio al Caffè Nero, cene in ogni angolo della cittadina, brevi viaggetti e pomeriggi in università. In Irlanda, sei stata per me una spalla nelle giornate più difficili ed una compagna di avventure eccezionale, perché hai sempre accettato ogni mia

proposta per farci compagnia e trarre il massimo da questa esperienza, che ha sicuramente contribuito a suggellare la nostra amicizia, la quale si è poi evoluta e non si è fatta intimidire dalla scelta di proseguire lungo due strade diverse per il percorso della magistrale. Anche se in questi ultimi anni ci siamo incontrate di meno, la volontà di aggiornarci sempre e di organizzare qualche rimpatriata non è mai venuta meno, anzi si è sempre rinnovata, culminando in qualche tua capatina tra le colline delle Langhe ed in qualche mia visita tra i monti del Biellese.

A Elena: sei stata l'ancora del mio percorso accademico, una presenza costante che ha affiancato ogni mio passo, dalle prime chiacchierate tra i banchi delle lezioni di diritto fino al conseguimento di questo secondo titolo. Senza di te, che come me hai scelto di cambiare strada dopo la triennale, l'avventura della magistrale sarebbe stata molto più impervia e stressante. Invece, la presenza di una persona vicina, sempre pronta a sostenermi ed aiutarmi quando ne avevo bisogno, mi ha dato il supporto necessario anche nei periodi più pressanti. La tua calma e gentilezza hanno conferito una maggiore stabilità e tranquillità alle mie giornate, dimostrandomi che qualsiasi obiettivo può essere più facilmente raggiunto se l'impegno viene accompagnato dalla capacità di non farsi prendere dall'affanno. Ti sono profondamente grata non solo per la positività che hai portato dentro le mura del Poli, ma anche per il rapporto di amicizia che abbiamo costruito fuori dai banchi, tra una crema al caffè al MixTo ed una colazione in qualche pasticceria delle zone, tra una partita alla Wii ed una gita fuoriporta.

A Francesca: nonostante ci conosciamo da soli due anni, l'intensità con cui li abbiamo vissuti ci ha portate a condividere spontaneamente risate e preoccupazioni, tra una lezione ed un'altra. Il tuo essere così scoppiettante e piena di energia ha portato una nota di divertimento e leggerezza anche nelle giornate più difficili, dimostrando che un clima di complicità e serenità può mettere in una luce diversa anche i periodi più storti.

Al professor Domenico Maisano: un ringraziamento speciale per l'attenzione e la cura che mi ha riservato nella stesura di questo lavoro, durante la quale i Suoi riscontri sono stati sempre celeri, puntuali e precisi. La passione e la dedizione che ho sempre percepito in ognuno dei nostri aggiornamenti ed in ogni sua lezione hanno confermato i miei pensieri circa l'impatto che un buon insegnante può avere su di noi studenti.

A tutti i miei insegnanti: a voi che mi avete accompagnata in questi ventuno lunghi anni, formandomi accademicamente ed umanamente, devo la persona che sono diventata. È dolceamaro, oggi, lasciare il mondo della scuola, perché, grazie a tutti voi, esso ha sempre rappresentato per me un porto sicuro, un luogo di crescita e valorizzazione, un ricordo tra i più preziosi. Un ringraziamento speciale lo riservo a voi: alle maestre Carla ed Eliana, per avermi presa per mano quando ero una piccola farfallina, accompagnandomi con dolcezza infinita lungo la strada per diventare un orsacchiotto e mantenendo vivo il ricordo di me, anche a così tanti anni di distanza; alla maestra Claudia, mia instancabile sostenitrice, per avermi dimostrato l'importanza della fiducia e della cura, scovando in me delle grandi potenzialità, in cui hai creduto fino in fondo, anche quando ho cercato di convincerti del contrario; alla maestra Daniela, presenza sempre amorevole, costante e certa, perché ancora oggi mi basta un solo tuo abbraccio per lenire le mie preoccupazioni…c'è un frammento nel mio cuore che sarà tuo per sempre; alla professoressa Anna Guida, ormai diventata amica, per avere acceso in me una passione profonda e mai sopita, che hai sempre alimentato, riponendo estrema fiducia e considerazione nelle mie capacità, della cui formazione hai gran parte del merito; alla professoressa Mara Chiavero, in cui ripongo una stima ed un'ammirazione profonde, per avere rappresentato tutto ciò che un buon insegnante deve essere, per la Sua professionalità e serietà estreme, affiancate ad una cura sempre materna ed attenta verso i miei bisogni; al professore Francesco Sobrero, a cui devo

l'inizio del mio percorso universitario, perché la Sua passione verso l'insegnamento mi ha risvegliata dal mio torpore, instillando in me una consapevolezza ed una fiducia che non avevo mai ritrovato, aprendomi le porte verso nuovi orizzonti; al professore Giancarlo Satragno, per avermi sempre sfidata a fare di più e meglio, perché la Sua ironia è stata il motore che mi ha fatto superare tanti ostacoli e prendere progressiva consapevolezza di me e delle mie potenzialità, per avermi lasciato un insegnamento tra i più preziosi, di grande aiuto in innumerevoli momenti lungo questo percorso…"Marta, devi ripeterti che va tutto bene. Se temi qualcosa di specifico quella è paura, e ci sta. L'ansia è una paura senza oggetto e deve essere bloccata. È la base della felicità, questa consapevolezza."

A Flavio: un grande e sincero grazie per avermi accompagnata in questa avventura conclusiva del mio percorso accademico, mostrandomi un'attenzione ed una sensibilità ormai rare, dedicandomi pazienza e competenza insieme ad un sempre sincero interesse verso tutte le mie proposte. La dedizione e la passione che quotidianamente riservi al tuo mestiere, accompagnate dalla tua grande umanità e gentilezza, hanno costituto per me un grande esempio, ispirandomi nel modo in cui sarò chiamata a gestire il mondo del lavoro.

A Lillo, Cristian, Aga, Vins, Fra e Michi ed a tutte le donne della Robino & Galandrino: grazie per avermi accolta come una di voi, facendomi subito sentire parte del vostro gruppo ed alleggerendo le mie giornate. Le pause caffè e le pause pranzo in vostra compagnia, così come le chiacchierate condivise alla scrivania, hanno rallegrato i due mesi trascorsi insieme, dimostrandomi che una risata in più è capace di migliorare anche i giorni più storti. A Michi, in particolare, un ringraziamento d'onore per la pazienza e l'attenzione infinite che mi hai sempre riservato, aiutandomi a finalizzare questo lavoro.

A zia Kaffy: fin dalla mia più giovane età, hai rappresentato per me una presenza costante e certa, interessandoti sempre del mio percorso e supportandomi con tutti gli strumenti che avevi a disposizione. Grazie per essermi sempre venuta incontro, proponendomi una colazione, una cena o una giornata insieme tutte quelle volte in cui, presa dall'affanno o dalla noia di giornate sempre uguali, ti ho chiesto di trascorrere qualche ora insieme. L'affetto che sei stata capace di dimostrarmi negli anni è sempre stato profondo e sincero ed io spero, in futuro, di poter rappresentare per la piccola Olivia anche solo una minima parte di ciò che tu sei stata per me.

A tutti i bimbi ed a tutte le bimbe del Piedibus, con una menzione d'onore per Linda, Olivia ed Emma: avete rallegrato anche le mie giornate più buie, perché una manciata di minuti in compagnia della vostra genuinità è sempre bastata per strapparmi un sorriso e raddrizzare le giornate più storte, perché la vostra innocenza mi ha spinta più volte a cambiare prospettiva ed a riconsiderare cosa è davvero importante, perché "se sei arrabbiata, mangiati una caramella, e tutto passa".

A me stessa: nonostante io non abbia mai raggiunto la certezza di aver scelto il percorso più in linea con il mio essere e con i miei ideali e nonostante io non abbia ancora davvero capito se la scelta di intraprendere questa avventura sia figlia di una profonda fiducia o di una folle incoscienza, sono però certa di una verità importante, ovvero della mia costante capacità di inanellare un passo dopo l'altro, di superare un ostacolo dopo l'altro, fino a raggiungere ogni obiettivo atteso. Oggi, quindi, voglio prendermi del tempo per riconoscere la strada percorsa fino a qui e per sottolineare a me stessa un grande insegnamento che il Poli mi ha lasciato. In questi anni, è stata probabilmente la percezione di avere intrapreso un'avventura totalmente al di fuori della mia zona di comfort che mi ha finalmente lasciata libera dall'ossessione di ricercare una perfezione ed un'impeccabilità inesistenti nella realtà della nostra sgangherata esistenza. È stata la consapevolezza di dover sfidare i miei limiti più radicati

e le mie debolezze più recondite che mi ha concesso il privilegio di trovare un bilancio tra dovere e piacere, tra sforzi e riposo, tra intransigenza e orgoglio, che non avevo ancora mai avuto modo di affinare. Voglio dunque riconoscermi, per una volta, il coraggio che mi ha guidata ogni giorno nel mettermi alla prova su un terreno per me molto sdrucciolevole; io, che odio i cambiamenti, i rischi e l'incertezza, mi sono imbarcata in un viaggio che di questi tre aspetti ne ha fatti i propri pilastri, dimostrando una resilienza nel perseguimento dei miei fini che si è alla fine forse rivelata più determinante e potente di qualsiasi dubbio. È con la speranza di una scommessa vincente che mi affaccio ora ad una nuova fase della mia vita, certa, nonostante tutto, che la forza che mi sono dimostrata in questa avventura sarà la stessa che mi darà modo di modellare i miei futuri passi sulla scia delle aspirazioni che il mio cuore mi rivelerà nel profondo.