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Use Of The DFMA Methodology To Develop An Improvement Project In The Picking Process

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Abstract:
Background: *The relentless pursuit of increased competitiveness in the national and international markets has led companies in general to identify new ways to streamline their processes and reduce industrial costs, aiming at constant improvements in productivity. With the emergence of lean manufacturing, many tools have been developed and made available to researchers and professionals. Clearly understanding the process combined with mastery of the tools, provides better conditions for developing a productive improvement project integrated with the product design. The general objective of this research is to analyze and design a picking process to improve productivity and competitiveness in a logistics operator through the Design for Manufacturing and Assembly (DFMA) technique.*
Materials and Methods: *Regarding the approach, this study is qualitative research, and in terms of objectives, it is classified as exploratory research. Within the exploratory research, the action research method was used, with the collection of information and analysis of the daily production report, automatically extracted from the company's Enterprise Resource Planning (ERP) system.*
Results*: After analyzing the entire production process, including the movements of employees and materials using the Design For Manufacturing and Assembly (DFMA) tool, the analysis and interpretation of the data obtained made it possible to develop a light picking project to replace the carousel picking that was already in operation, ensuring that daily demands were met and increasing the total quantity collected from 1,694 skus to 8,470 skus, solidifying the company's production capacity for the customer.*
Conclusion: *Using the tools, it was possible to evaluate the current process, identify opportunities for improvement, and develop scenarios for approval by senior management regarding the model to be implemented, in addition to demonstrating the preliminary estimated gains.*
Keyword: *DFMA; Picking; Continuous improvement; Project process.*

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I. Introduction

Design for Manufacturing and Assembly (DFMA) is an approach that optimizes the manufacturing and assembly of products by considering these aspects from the initial stages of the design process. This allows for process simplification, reduced complexity, and minimization of additional parts. The application of DFMA results in lower costs, shorter production times, and improved product quality.

Furthermore, DFMA promotes integration and collaboration between design, manufacturing, and assembly teams. Effective communication between these teams is essential to ensure that design decisions are implemented correctly and to take full advantage of opportunities to optimize production processes.

According to a study by Koufteros (1), the correlation between product platforms, concurrent engineering, and manufacturing methods observed that company performance is affected by product development strategies and manufacturing practices.

DFMA is an approach that integrates manufacturing and assembly considerations from the beginning of the project, resulting in cost reduction, quality improvement, and increased efficiency. To achieve these benefits, collaboration between multidisciplinary teams and the use of appropriate tools to optimize processes are essential.

This article highlights some commonly used tools and techniques in DFMA, such as process flow diagrams and value analysis. These tools provide structure and guidance for identifying bottlenecks and improvement opportunities, allowing designers to make informed decisions during the design process. The picking process, which involves collecting products in a warehouse to fulfill customer orders, is essential in logistics and distribution operations. Two widely used approaches for this task are carousel picking and pick-to-light.

This article will also provide a comparative analysis of these two systems, discussing their characteristics, advantages, and disadvantages, based on specialized bibliographic references and a case study in a logistics operator. Carousel picking has proven efficient in high-density storage environments, optimizing collection time, and reducing human errors. Pick-to-light, on the other hand, is suitable for high-turnover inventory environments where accuracy is critical, as it reduces the time needed to locate and pick products, significantly improving productivity.

Comparing the two picking systems:

i. Efficiency and Productivity: Picking to light is faster and more efficient, directing the operator to the right item and reducing travel time, while picking by carousel requires manual searching (2).
ii. Accuracy: Picking to light is more accurate, eliminating many human errors, unlike picking by carousel, where incorrect selections can occur (3).
iii. Implementation Cost: Picking by carousel has a lower initial cost, as it does not require the installation of light displays, making it a more economical option (4).
iv. Flexibility: Picking by carousel is more flexible for adjustments to the warehouse layout, while picking to light may require changes to the lighting system when reorganizing the stock (5).

Both picking systems have their advantages and are effective in different logistics contexts. The choice between them should consider the specific needs of the company, such as stock type, order volume, desired accuracy, and budget. In some situations, combining both systems may be the ideal solution for an efficient and accurate picking process.

The general objective of this research is to study the current picking process and propose a new, more efficient model using the Design for Manufacturing and Assembly (DFMA) technique. This general objective was divided into the following specific objectives:

-Evaluate the current process using Value Stream Mapping (VSM).

-Develop and implement a new picking process using DFMA.

II. Literature Review

Design for Assembly (DFA)

DFA provides design engineers with knowledge about assembly issues, allowing for anticipation and improvement along with the design (6).

The simplicity of the assembly process does not depend solely on the item and its characteristics, but depends on the process of material supply, handling, and assembly procedure (7).

The objective of this method is to make the process simpler and reduce the total cost in addition to the time spent on assembly (8).

DFA is widely applied in several industries, including automotive, electronics, home appliances, and many others. The methodology is especially useful for products with large production volumes, in which small improvements in the assembly process can result in large savings in time and money.

There are several fundamental principles of DFA that should be considered during the design process. Some of these are:

I. Minimizing the number of parts: The fewer the number of parts, the easier and faster the assembly process will be. This includes reducing the number of individual components and integrating functions into a single part whenever possible.
II. Standardization and modularization: The use of standardized elements and prefabricated modules makes assembly easier, as the parts are designed to fit together perfectly. In addition, modularization allows for the rapid replacement of defective components or the updating of a product without affecting the entire assembly.
III. Accessibility and visibility: Designers should ensure that assembly areas are accessible and visible. This makes it easier to insert parts, connect components, and check for errors during the assembly process.
IV. Design for automation: Where possible, DFA should consider the possibility of automating assembly. The design should include features that allow for the use of machines and robots to perform repetitive, high-precision tasks.

Effective implementation of DFA can bring several benefits to companies, such as:

a. Reduced production costs: By simplifying the assembly process and reducing the number of parts, production costs are significantly reduced. Fewer parts mean less time spent on assembly and fewer materials required.
b. Increased product quality: With a design optimized for assembly, errors or failures are less likely to occur during the production process. This results in higher quality products and greater customer satisfaction.
c. Reduced production time: DFA enables faster and more efficient assembly, thus reducing the time required to produce a product. This leads to increased productivity and a faster response to market demands.

The direct advantages represent a reduction in fixed and variable assembly costs, whether manual or not. An item designed using DFA principles requires fewer machines and assembly specialists and reduces the difficulties of assembly activities.

Indirect advantages are the simplification of inventory control, increased reliability of the item, reducing warranty time, and maintenance costs (6).

Design for Manufacturing (DFM)

Design for Manufacturing (DFM) is a strategic approach adopted in industry to optimize the product manufacturing process from the initial stages of project development. It involves several factors, such as appropriate material selection, manufacturing methods, assembly processes, and dimensional tolerances (10).This approach is aimed at ensuring that the product is manufactured efficiently, economically, and with high quality (9).

According to Jones (10), one of the main principles of DFM is design simplification. Authors such as Brow & Wilson (11), highlight that this principle entails the elimination of unnecessary components, reduction of parts, simplification of assembly processes, and reduction of overall complexity. Design simplification not only simplifies manufacturing, but also reduces production costs, and improve product reliability.

Collaboration between design and manufacturing teams is essential in DFM (12). Efficient communication and knowledge sharing between these teams ensures that manufacturing requirements are considered from the initial stages of design (13). Implementing DFM requires a multidisciplinary approach, with the participation of design engineers, manufacturing engineers, materials experts, and other relevant stakeholders (14).

Several methods and tools are available to assist in the implementation of DFM (15). For example, value analysis, design for disassembly and assembly (DFMA), simulation of manufacturing processes, and the use of rapid prototyping are widely used techniques (16). These tools help to identify potential problems, evaluate design alternatives, optimize manufacturing processes, and make informed decisions during product development.

The use of DFM practices has illustrated an orderly and effective way of implementing the method in manufacturing situations (17). Designers must consider manufacturability to meet the objectives of simplifying the manufacturing process and aligning the design with the procedure to obtain optimal results (7).

The application of DFM can produce numerous advantages for the company, decreasing production cost, speedier development time, enhanced quality and reliability, increased manufacturing efficiencies, and providing greater customer satisfaction. In these objectives, manufacturability-oriented design must be applied from the very start with integrated coordination between the design team and the manufacturing team.

Design for Manufacturing and Assembly (DFMA)

DFMA involves considering the manufacturing and assembly process during the initial stages of product design. By designing with ease of manufacture and assembly in mind, it is possible to avoid problems and challenges that could arise later during mass production (9). The DFMA approach can be divided into two main stages, where the Stage one is the Design for Manufacturing (DFM) and, secondly, Design for Assembly (DFA) (10).

The studies conducted by Johnson et al. (12), help to deal with expenses, enabling designers to use assets more effectively, reducing costs, and improving business indicators.

A general overview of the procedure for DFMA analysis is to identify the product on which the analysis will be performed. After selection, the product is individually disassembled, and the parts are modeled in CAD software (18). DFM cost analysis is performed on individual parts to define a product design cost baseline and DFA analysis to identify candidates for elimination (8).

Thus, implementing DFMA can shorten lead time since, during these phases of development, essentially the making and assemblage processes can be optimized by improving the manufacturing and assembly process from the early design phases, it is possible to shorten development and production cycles. Hence this in turn would help firms to respond with agility to market demands, thereby giving them an edge over their competitors.

In short, DFMA is an important strategic tool used to optimize the manufacturing and assembly process of industrial end-products; concurrently, DFMA also achieves a means by which costs are cut, quality is enhanced, and production efficiency is increased through consideration of the capabilities and limitations of manufacturing in early design phases. In effect, selling points for DFMA implementation include ends like reduced costs, better quality, and shortened time-to-market. Use of appropriate tools and processes is an integral part of a successful DFMA implementation.

Picking by Light

Picking by light or picking to light is an order collection method that uses light technology to assist in the process of separating items in a warehouse or distribution center. This system is widely used in sectors such as logistics, retail, and e-commerce, with the aim of increasing efficiency and accuracy in order preparation (9).

The picking process is a critical step in warehousing and distribution operations. Traditionally, workers are responsible for walking through aisles and shelves in search of the requested products, which can be timeconsuming and prone to errors (10). Picking to light uses indicator lights in each storage location to indicate to the operator which item should be selected. These lights are automatically activated by a management system, which receives order information and determines the most efficient picking sequence (13).

The use of picking up light offers several advantages over traditional order picking methods. First, light technology allows for faster and more accurate location of items. By illuminating the specific storage location, the operator can easily find the desired product, reducing the search time. This results in a significant increase in productivity, especially in large distribution centers where the distance traveled by workers can be considerable (12).

According to Black & Wilson (18), picking to light also helps minimize errors during the picking process. Indicator lights prevent confusion by ensuring that the operator selects the correct item. This is especially important in operations that manage a wide variety of products, where confusion between similar items can occur more frequently. The improved accuracy of picking to light contributes to customer satisfaction, as it reduces the number of shipping errors and the need for returns (14).

Another advantage highlighted by Wang et al. (15), is the possibility of tracking data in real time. With the management system connected to the lights, it is possible to monitor operator performance, identify bottlenecks in the picking process, and make necessary adjustments. This data can be analyzed to optimize warehouse layout, define routing strategies, and determine best work practices (11).

It is worth noting that implementing picking to light requires investments in infrastructure and technology (9). It is necessary to install indicator lights at each storage location, connect these lights to a centralized system, and train operators to use the system correctly. However, the benefits of increased efficiency and accuracy outweigh the initial costs, especially in operations with high order volumes (13), (14).

Carousel Picking

Carousel picking is an order picking method widely used in warehouse and distribution center environments. In this system, items are stored on shelves or racks around a circular conveyor device known as a carousel. As orders are received, the carousel rotates to bring the shelves with the required items to the operators, making the picking process more efficient and productive (19). In this theoretical framework, we will explore the benefits and challenges of carousel picking as well as discuss its applicability in different industries and the importance of proper planning and management.

Carousel picking offers significant advantages over traditional order picking methods. One of the main advantages is the reduction in travel time for operators. Since the shelves are brought directly to the operators by the carousel, they do not have to travel long distances in the warehouse in search of the desired items. This results in increased productivity and efficiency in the picking process, allowing a higher volume of orders to be fulfilled in a shorter period (10).

In addition, carousel picking also helps to minimize errors during the picking process. Items are organized in an orderly fashion on the carousel shelves, making it easier to identify them correctly and reducing the likelihood of product mix-ups. This is especially beneficial in operations with a large variety of products and complex orders (13).

However, there are some challenges associated with carousel picking. One of them is the need for careful planning to optimize the arrangement of items on the carousel shelves. The proper arrangement of products directly influences the efficiency of the picking process, ensuring that the most frequently requested items are strategically positioned. In addition, it is important to consider the load balance between the carousel shelves to avoid overloads or imbalances that could compromise the system's performance (12).

The applicability of carousel picking varies according to the sector and type of operation. This method is particularly effective in environments with a large number of SKUs (Stock Keeping Units) and a high average demand. Industries such as retail, e-commerce, pharmaceuticals, and parts distribution are examples of sectors in which carousel picking has been widely adopted. However, it is important to consider that the implementation of this system may require significant investments in infrastructure, such as the installation of carousels and automated control systems (18).

Finally, authors such as Wang et al. (15), emphasize that proper planning and management are essential for the success of carousel picking. It is essential to conduct a detailed analysis of operational requirements, such as order volume, product variety, and demand patterns. Based on this data, it is possible to design an efficient layout, determine the appropriate number of carousels, and define the most appropriate picking strategies. In addition, operator training and the implementation of accurate inventory control systems are crucial to ensuring the accuracy and efficiency of the process.

Value Stream Mapping (VSM)

Value Stream Mapping (VSM) is an effective tool due to its characteristics in mapping the entire process flow and its benefit and identifying the steps that do not add value in the manufacture of a product or service, from the supplier to the customer (20).

VSM shows how each process is, with the timing of proceeding to the customer's needs of the next process, with all the movements of materials and information. The sources of losses are identified and in the planning of the future state, are eliminated, considering the entire value chain and not just the individual local processes (21).

In any manufacturing industry, operations can be classified into three main genres: non-value-adding activities (NVA), but necessary; non-value-adding activities (NVA) but unnecessary; and value-adding activities (VA). Activities (ANVD) do not add value to the customer or the company; they form waste and need to be eradicated (unnecessary handling, reprocessing, waiting time, etc.). To present the production processes in a schematic way, symbols that represent products, operations, and information flows are used (22). Based on the analysis of the mapping of the current state, a new process design is developed with the value stream map projecting the future state (23).

Times and Methods

According to Slack & Johnston (24), agility in decision-making, material movement, and internal communication within the operation is very important, providing benefits such as reducing inventory, reducing risks, and helping to respond quickly to external customers. On the other hand, wasting or using time inappropriately can result in additional costs during the operation.

The objective of measuring work times was to define the best way to develop a specific task, a methodology that has remained practically unchanged since that time. Task timing continues to be widely used in most Brazilian companies with the aim of measuring and evaluating work performance (25).

According to Gaither & Frazier (26), it can be said that work measurement is related to the process of estimating the amount of time an operator needs to generate a production unit and, its ultimate goal is almost always to develop high-productivity labor standards.

Slack & Johnston (24), state that time study is a work measurement technique widely used to record times and work progress for elements of a given task, generally performed under predetermined conditions. The data obtained are analyzed to obtain the time required to perform the work and define its level of performance.

According to Peinado & Graeml (25), work sampling is a technique that allows estimating the percentage of time that a worker or machine uses in each activity. Continuous observation or timing of the activity is not necessary, according to L.H.C. Tippet, in the English textile industry. In 1940, in the USA, it was implemented under the name of waiting ratio, and its use gained more popularity from 1950 onwards. Currently, it is more widely used than timekeeping, since the increase in the number of service organizations requires techniques that are faster and more comprehensive (25).

Industrial Layout

Industrial layout plays a fundamental role in the operational efficiency of a production facility. This research addresses the study of industrial layout, concepts, optimization methods and its importance for the organization.

Layout refers to the spatial organization of production resources in a factory or facility. It encompasses the arrangement of equipment, machines, work areas, stocks, and material flow. A well-planned layout can reduce transportation times, increase labor efficiency, optimize the use of space, and facilitate communication between different sectors. Below are the main concepts addressed for a layout study:

- Importance of industrial layout: An inadequate layout can result in production bottlenecks, waste of resources, rework, and lack of flexibility for future adaptations. A well-designed layout, on the other hand, can result in greater productivity, cost reduction, improved product quality and improved employee safety.
- Factors to consider in layout: Several factors must be considered when planning an industrial layout, including process flow, communication needs, ergonomics, safety, regulations, and specific demands of a sector. A layout must be flexible enough to accommodate future changes and expansions.
- Planning methods: There are several approaches to industrial layout planning. Some of the most common methods include process layout, in which machines and resources are grouped by process similarity, and product layout, which organizes areas according to the product’s production sequence.
- Analysis and optimization tools: Varieties of tools assist in the analysis and optimization of industrial layouts. Computer simulation allows you to evaluate different scenarios and identify potential bottlenecks before implementation. Additionally, quantitative methods, such as material flow analysis and process mapping, help identify areas for improvement.

- Advanced technologies and Industry 4.0: Industry 4.0 has brought significant advances to the study of industrial layout. IoT sensors can collect real-time data on material movement and resource usage. Artificial intelligence algorithms can analyze this data to dynamically optimize the layout and identify opportunities for continuous improvement.
- Case Studies: Several case studies illustrate the importance of industrial layouts. Toyota's assembly line reorganization using Toyota Production System principles resulted in significantly improved efficiency and quality. Fashion retailer Zara adopted a flexible layout that allows rapid changes to adapt to changing fashion trends.
- Conclusion: Industrial layout studies play a crucial role in the pursuit of operational efficiency and competitiveness. A well-designed layout can improve productivity, reduce costs, and enhance product quality. With the continued evolution of analysis and optimization technologies, organizations have more tools at their disposal to create highly efficient and adaptable production environments.

III. Material And Methods

This research is justified by the importance of a detailed analysis of the picking process and the proposal of a new model that is appropriate to the current and future demands of the client. This research was conducted between July 2021 and June 2022, and it is important to note that monitoring should be ongoing to continuously improve the process. The expected result of this research is the development of a competitive picking process, reducing current time, avoiding errors, and adding value to the client.

After analyzing the collection process of the company studied, it was found that the daily separation capacity was insufficient in relation to the client's demand, causing delays in delivery and failure to meet the monthly volume required. Given this scenario, it was decided to review the production process and propose plausible solutions to reverse the situation for the client.

At the end of the research, the results show that with the application of the tools, it was possible to analyze and propose a new, faster, and more reliable separation and collection process, with the capacity to meet the client's demand at a lower cost.

The methodological procedure applied in the project details the steps taken during its construction, with the aim of clarifying the location, objectives, research instruments, as well as data collection and analysis. Although sciences are defined as procedures that use scientific methods, not all works that employ these methods can be classified as sciences. Therefore, scientific methods are not exclusive to science; however, what is achieved without the support of scientific methods cannot be considered science (27).

The method can be defined as a way of proceeding along a path using a group of systematic and rational activities, which allow the generation of valid and true knowledge, assisting in the decisions of a scientist or a researcher in the company in an economical and safe way (27). Figure 1 shows the sequence of activities developed throughout the research.

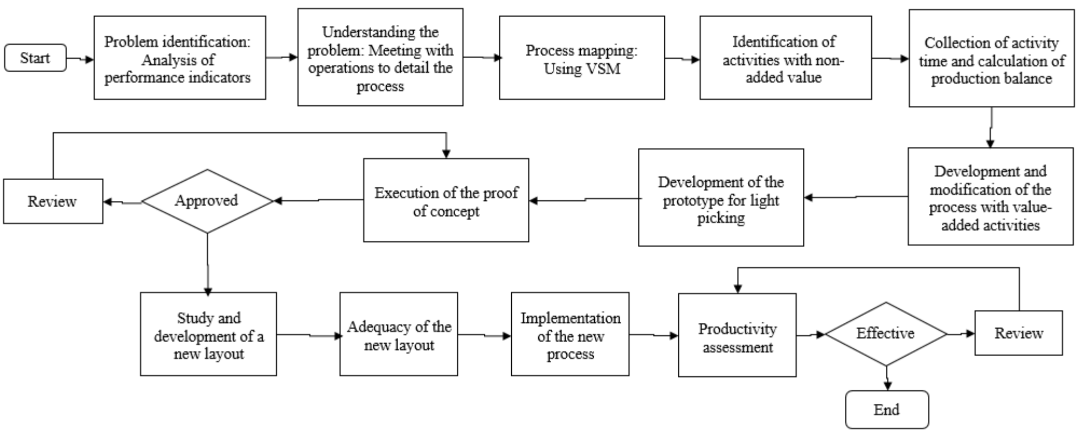

Figure 1- Research activity flow

The development of action research is divided into eight phases presented in the literature by McKay & Marshall (28), detailed in Figure 2.

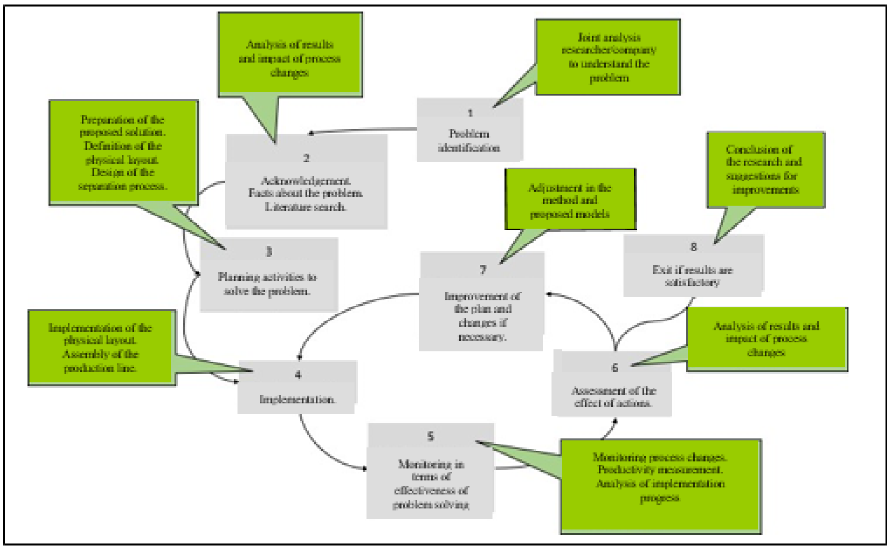

Figure 2 – Flow of research activities

The steps illustrated in Figure 2 are described as follows: Step 1, Problem identification, consists of the researcher's task of identifying the problem he or she is interested in solving. Step 2, The researcher must strive to promote a broad literature review in search of theories that can support the solution to the problem. Step 3 consists of developing an action plan to solve the problem. Step 4, the action plan developed in step 3, must be put into practice. Step 5 consists of monitoring the actions implemented to see if the results obtained are in line with expectations. Step 6, In this step, the effect of the actions must be evaluated. This is a decision point. If the actions have solved the problem, go directly to step 8. If not, corrective actions must be implemented in step 7. Step 7, This step should be implemented if the action plan developed in step 3 requires adjustments. Step 8 is the conclusive step where the problem must be solved and the objectives achieved (table in this paragraph).This research was developed at a 3PL logistics operator, specifically in the jewelry separation and shipping process, where the main opportunity for improvement was that the daily volume shipped was not able to meet customer demand.

The daily volume shipped was not meeting customer demand, resulting in delays and the need to work overtime. Returns due to separation errors and complaints contributed to the decision to analyze the current process, measure activities and times, providing support for the development of a new separation and shipping method.

The DFMA methodology was chosen due to the need to simplify the process, reduce separation costs and optimize the sequence of activities.

The initial mapping of the process was done using the VSM (Value Stream Mapping) quality tool, applied to the separation and shipping process of items requested by the customer.

A time and motion study were conducted in the area, identifying the longest process steps. The detailed analysis showed that the total process time was not enough to process the quantity of items requested by the customer. Since the picking process was conducted using a carousel, the time required to collect each item was linked to the operating speed of the carousel itself. This led to the analysis of other ways of conducting the separation and, depending on the available physical space, the option was to use light-based picking.

Initially, a cabinet was designed to store the items and, in parallel, a lighting system was developed to indicate the position where each item was stored. The results obtained validated the decision to replace the carousel with light-based picking.

IV. Result And Discussion

When studying the process steps, it was identified that the daily volume separated was limited by the carousel's operating speed. The picking step consists of identifying the item in the collection order, selecting it on the carousel, observing the position of the BIN box on the tray and collecting it. Carding means checking the collected item and separating it by customer. The packaging step can be divided into two forms: with or without a jewelry box, which changes the total process time.

Figure 3 shows the carousel screen with the layout of the selected tray, indicating in yellow the BIN box in which the item to be collected is located.

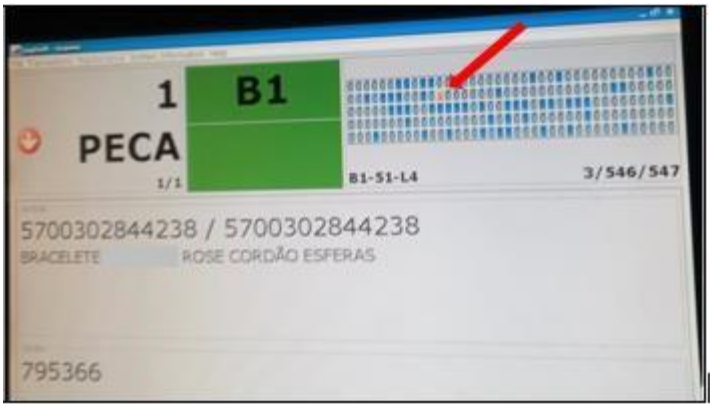

Figure 3 – Image of the carousel screen with the selected item.

Since the trays are not identified with rows and columns (Fig. 4), it takes time to correctly identify the BIN, in addition to the risk of collecting the wrong item.

Figure 4 – Image of the carousel tray.

Initially, the trays were identified by row and column criteria, with rows identified with numbers and columns identified with letters, synchronizing the identification of the trays with the identification on the electronic panel. Once the identification of the trays was completed, the BIN boxes were resized, adapting the layout of all the trays to the demand for the items. This study allowed an increase in the number of SKUs stored per tray, as shown in Figure 5.

Figure 5 – Image of the carousel tray.

It can be seen in Table 1 that after resizing the BIN boxes and layout, the total storage capacity increased to 11,780 SKUs, much higher than the 2,463 prior to the change.

	Jess Tray 1	Jess Tray 2	Hawkers	New Layout
Qty. of trays	29	29	4	62
SKU per tray	56	27	14	190
Total SKU	1624	783	56	11780

Table 1 - Comparison chart between layouts

In parallel with the changes in the operation, an electronic system was developed to control the operation of light picking. The screen shown in Figure 6 was created so that operators can access the system using their functional identification and individual password.

Figure 6- Screen for employee identification and access

Once the system is accessed, the first step is to enter the identification of the position where each item will be stored, as shown in Figure 7, creating a reliable database that speeds up collection.

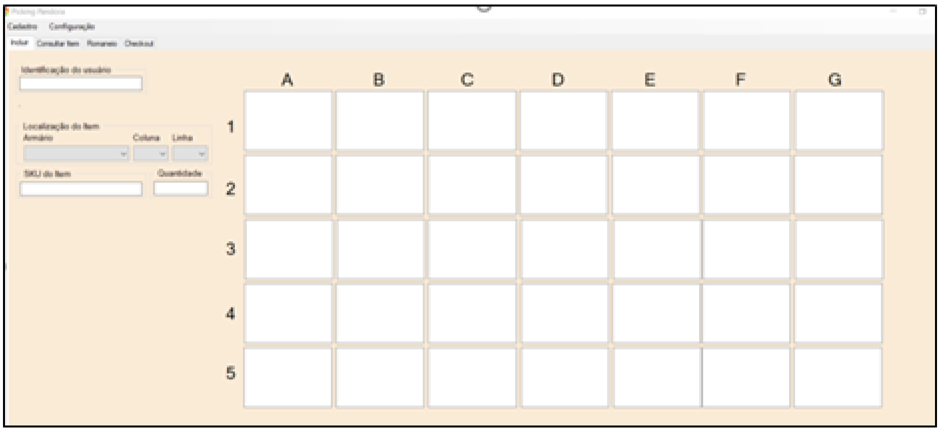

Figure 7- Screen indicating the location where the item will be stored.

The system also allows you to consult the lease simply by entering the SKU code, see Figure 8.

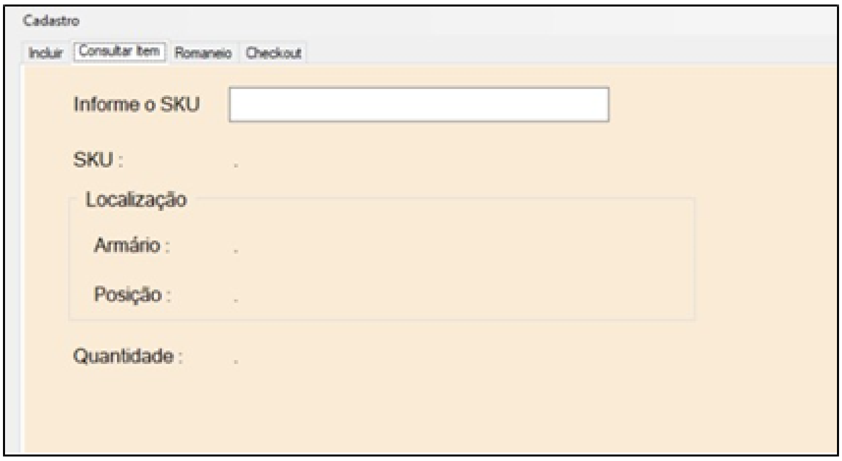

Figure 8 - Screen for checking the location of the stored item.

The collection process begins with the identification of the employee and information on the delivery list that they wish to collect (Figure 9). The system reads the SKUs on the delivery list, checks the location, and informs them by turning on the respective lights.

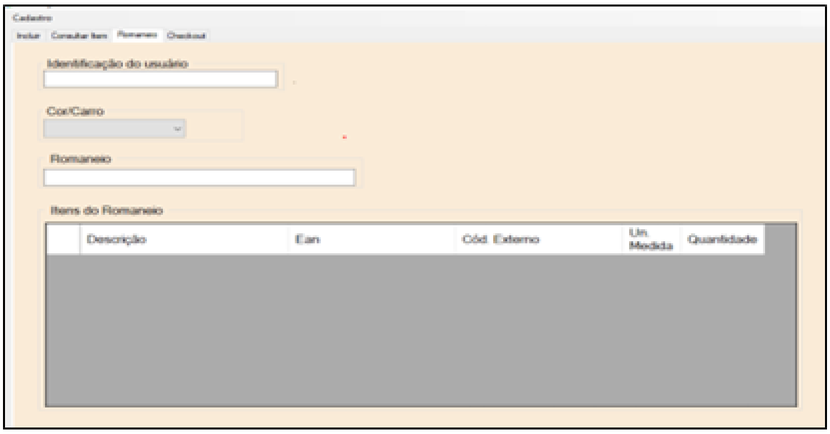

Figure 9 - Screen that identifies the employee who will perform the collection.

Once the lights are turned on (Figure 10), the employee goes to the item, collects it, and informs them via radio frequency that the collection has been completed. The system, in turn, turns off the LED and removes the stock. The employee moves to the closest item and repeats the operation until all items have been collected.

Figure 10 - Prototype with LED indicator

To speed up the process, LED strips were used and started with five distinct colors, that is, each employee receives a color at the beginning of the shift and only collects items of their respective color. This alternative makes it possible to process five different and simultaneous lists.

In Figure 11, it is possible to identify three distinct colors (blue, white, and red), simulating the simultaneity of the process, evaluated in a proof of concept.

Figure 11 - Prototype with colored LED

After the process was validated in the proof of concept, the final project with dimensions of all SKUs and layout design was developed for definitive implementation in the operation.
Figure 12 illustrates the final cabinet with the LEDs in the position determined by the layout design.

Figure 12- Final cabinet implemented in the operation.

The layout design shown in Figure 13 was designed to reduce movements and group items with higher turnover. The arrangement of the cabinets allows employees to move around the entire area, making it easier to see the LEDs on, reducing collection time.

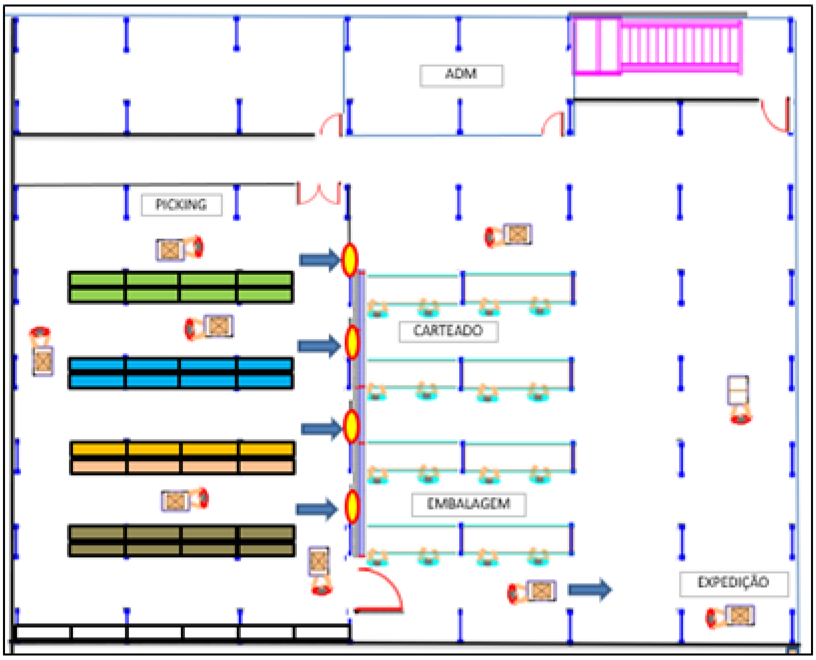

Figure 13 – Production layout after

With the adaptation of the new layout, there was a significant reduction in the time for collecting and separating materials, including allowing prior planning of the number of separators needed for the workday.

V. Conclusion

By applying the aforementioned tools, it was possible to analyze the current process, identify opportunities for improvement, develop scenarios for approval by senior management regarding which model would be implemented, and demonstrate preliminary projected gains.

The improvements implemented were monitored and validated by senior management together with the client, who, upon noting the real increase in production capacity, reduction in delivery time, and flexibility to absorb changes in demand, has gradually increased the placement of orders, strengthening the commercial relationship between the companies.

Table 2 shows a comparison between the processes with the steps and operating times for collecting an item using the light picking process.

	BEFORE			AFTER
	Operation	Description	Time (S)	Time (S)
Picking	1	Tray selection	35	0
	2	Item collection	15	8
	3	Check	5	0
	4	Reading and download	25	5
		Total	80	13
Check	5	Label beep	2	2
	6	Check	2	2
		Total	4	4
		Total process	84	17

Table 2– Comparison between processes

In the carousel separation process, the average daily quantity of separated items, considering an 8-hour workday, is 343 SKUs per employee. With the implementation of light picking, this quantity becomes 1,694 SKUs, with the possibility of performing the activity with five simultaneous operators, that is, separating 8,470 SKUs in the same shift. In addition, it provides flexibility to the operation to absorb variations in customer demand.

For the case studied, it became evident that switching to a light picking process was crucial for optimizing operations and surpassing customer expectations. The customer closely monitored and validated each step of the transition, ensuring transparency and confirmation of the results.

Whatever the proposed process change, it must be done based on the selection of appropriate tools for studying and solving problems. The methodology applied in the research will continue to be the subject of future studies in other areas of the company, ensuring continuous improvement of the processes.

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