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Layout evaluation to improve picking process in a boat company warehouse

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Abstract: The high concern of companies and their commitment to the reduction of lead times, combined with the growing variety of products, which is increasingly evident, is of extreme importance. Also important is the focus on improving logistical operations, many of which are registered within the warehouse itself, both for raw ma-

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terials and finished products. This work aims to analyse and suggest improvements in the layout of the raw material warehouse in a yachts production company, to reduce the picking time process. For this, it was necessary to understand if the layout warehouse was the most appropriate, or if it had to be reorganized in a different way. Each picking list is assigned a collaborator and has several different stations, consequently, representing different parts of the production of the boat. Internal and external recognition of the company was made so that it was possible to understand working methods and analyse all the flows related to the four production lines. Then the collaborators were monitored to understand their methodologies and the way they worked, as well as the main difficulties they felt. The data relating to the distances and picking times, of the respective boat models selected according to the production process, were collected, and analysed and a new layout was proposed. According to the results obtained with the proposed layout, the picking time was reduced by about 23%, the picking distance was reduced by about 32% and, at the same time, the picking flows and materials organization were improved, responding to the company objectives. In conclusion, the company has an advantage in modifying the layout of the warehouse oriented to the layout per station.

Keywords: Layout; Warehouse management; Picking process; Materials flow.

1. Introduction

Competitiveness in the globalized market requires companies to be agile and efficient in all stages of the process, from the supply of raw materials to the delivery of finished products to customers [1]. The operations carried out at the warehouse level are essential for a company to stand out in its sector, thus increasing its competitiveness compared to competing companies. Carrying out storage operations correctly and a good flow of materials from the entry of raw materials to the exit of the final product is essential to guarantee the good performance of the entire supply chain. Thus, the correct management of warehouses is essential for a good performance of the entire company [2]. All operations carried out in the warehouse are extremely important and should be one of the fundamental concerns of companies since they are a source of cost and of most errors ([3],[4]). This project was carried out in the warehouse of a company belonging to the naval sector. With the continuous growth of the company's production, one of the main needs was to reduce the response time to customers and subsequently reduce the time it takes for raw materials to be delivered to production.

The general objective of the project is the analysis and suggestion of improvements in the layout of the company's warehouse. The specific objective of carrying out this project is to reduce lead times, mainly by reducing the time and distances travelled during the raw material picking process. The methodology used throughout the project is very broad, in the sense that it can serve as a model for application in any other company, even if not in the same sector. Thus, the main problem of the study concerns the management of warehouses. The paper is divided into 5 chapters. The first chapter serves as the introduction, providing an overview of the topic, the second one is dedicated to the literature review, where the necessary theoretical concepts are defined. In the third chapter, the methodology employed in the study is outlined, detailing the analytical approach used. Moving on to the fourth chapter, it focuses on describing the company under study, conducting a diagnostic analysis of the current situation, and presenting proposed solutions to address the previously identified problem. Finally, the fifth chapter concludes the work, summarizing the key findings and offering insights and recommendations based on the study's results.

2. Literature review

Logistics is essential for companies, institutions, and organization, as it has its roots in military practises and involves managing the movement and transportation of goods and resources. However, the military area is not the only influence, it is also based on concepts related to the strategic area, the area of information systems, areas of technology, among others [5]. Logistic expansion has received greater importance in the last 20 years [6]. The main use of logistics is to guarantee consumers the right products, in the right conditions, right quantity, in the right place, at the right time with the lowest possible costs [7]. The correct management of a warehouse is undoubtedly one of the most important parts of supply chain management, being seen as a differentiating factor between companies in the same sector [8]. All operations carried out in the warehouse are extremely important and should be considered as one of the main concerns of companies, since it is one of the main sources of costs and where most errors occur [9]. The basic warehouse processes can be divided into six distinct operations (Figure 1). The reception, checking and storage that concern the entry of materials into the warehouse, while the remaining three operations, picking, preparation and expedition are operations that are directly related to the exit of materials from the warehouse [10].

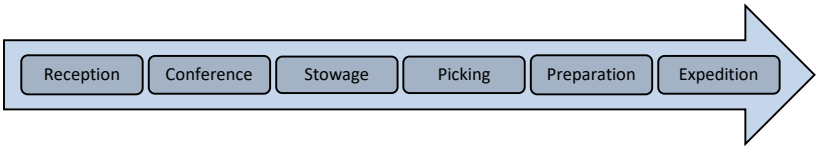

Figure 1. Basic Storage Operations. Source: Adapted from (Carvalho et al., 2010)

For the study carried out, the main warehouse activity analysed was picking. Picking is an activity that is triggered by customer orders, consists of collecting raw materials or finished product to later be prepared, packaged and shipped [11]. The picking activity must have the purpose of either dispatching the collected product or replenishing production/assembly lines [12,13].

There are several existing picking strategies, among which we can highlight four, picking by order, picking by line, zone picking and batch picking. In picking by order each picker only works on one order at a time and is characterized by having a low level of error, however, it is very unproductive, as the distance travelled by the operator is quite high. In picking by line, each operator waits for a certain number of orders to accumulate and, subsequently, the picker checks which products are common to the various orders and collects the total quantity of each product. Finally, it distributes the quantities of that product among the various orders. This type of strategy has a great advantage, which is increased productivity by reducing operators' transit time; however, it increases the risk of errors.

In zone picking, the warehouse area is divided into zones in which each picker is assigned a zone. Each zone has assigned certain products. The items collected in each zone are later consolidated so that the final orders are complete. This strategy has several advantages, increased productivity compared to picking by order and reduced congestion in the runners. On the other hand, it also has disadvantages, namely the possibility of errors occurring, as orders need to be consolidated again. Finally, batch picking is similar to picking by line, each operator is responsible for one type of product at a time, the only difference is in scheduling a certain number of orders throughout the shift. It consists of carrying out picking by line only for a group of orders and not for all of them [14].

When a company intends to define a new layout, there is a set of objectives that must be taken into account, namely, to ensure maximum use of available space, the minimization of movements by operators, the correct handling of materials, plan and control the movements and location of products, ensure the safety and conditions of employees and that the layout is flexible in order to allow future changes that may be necessary to make in it [15,16].

It is increasingly important for companies to invest in information technologies to streamline the supply chain and make all processes faster, thus allowing shorter lead times. Enterprise Resources Planning (ERP) consist of software that encompasses information from the various departments of a given company, thus making it possible to store all the organization's information [17,18]. This software allows the internal and external sharing of information, which represents one of the greatest competitive advantages of companies.

3. Methodology

This case study was developed based on the action-research methodology, consisting of criteria and methods, which infers theories about educational action [19]. This methodology gains consistency compared to other methodologies, in the sense that it imposes itself as an "action project" that carries "action strategies" [20,21]. Within the framework of this methodological process, we observed a set of phases, such as planning, action, observation, reflection, evaluation and reformulation. In the development of the project, the following steps were outlined:

1. Analysis of the picking process, times and distances, and the main problems throughout the process.
2. Realize what types of parts/raw material were common among pick stations of the rigorously worked boat lines, understanding and concluding the decision plan as it stands warehouse arranged.
3. Understand how many pallets are arranged on each shelf to understand whether the way in which the material will be distributed is proportional to the capacity of the warehouse.
4. Understand the entire picking process and the current layout, propose a new layout for the company.

4. Case study analysis

The company in which the study took place is a subsidiary of an American corporation. This belongs to the naval branch and is dedicated to the production of yachts of three different brands. Within these same brands, there are several models sold and produced by the company and, therefore, each one has its respective dimensions, characteristics and complexity. As previously mentioned, the company is dedicated to the production of yachts using fiberglass and resin. The production process involves the production of various intermediate products called: Big Parts, Medium Parts and Small Parts, which are later combined to form the final product. Moreover,

various accessories are also added to the final product, such as: rudders, engines, upholstery, radios, columns, decorative ribbons, and others. Currently, all the boats manufactured by the company have a length that oscillates between 4.4 and 8.5 meters. The company currently produces a total of 40 different models of boats.

4.1. Diagnosis

The company in terms of warehouse space is limited, and this fact, combined with the rapid growth and high increase in production, made it necessary to reduce the warehouse to increase the space dedicated to the production lines, which led to increased complexity in the management of stocks, material flows and the picking process, not only because it has less space but because it has more material and more references. Based on this, the flow of materials and people during the picking process and the consequent supply to the production lines were analyzed, as well as the associated times and distances to identify improvement proposals.

The company produces boats of various sizes, correspondingly, line A, B, C, and D, completed by stations assigned to each boat, designated by the raw material required, to the Pre-assembly, Pick, Final, Packaging, and Teak stations (determined optionally by the customer).

Through the identification of problems, we highlighted the fact that each pick sheet has several references for several locations and, therefore, in order to reduce picking time and travel, the tendency to adapt picks from the same station of different boat models, is frequent.

Concerning the layout, it causes limitations at the circulation level, due to the physiognomic characteristics of the warehouse, the flow that is provided is not the best, because the obstructed aisles are visible, taking into account the circuit made in "zig--zag", regardless of the boat line, as well as, the need to have pallets of material on the floor of the aisles, due to the lack of space.

However, not only because of warehouse space limitations, but also because of the size of certain materials, as there is not only raw material inside, but also outside, causing more and extensive travel.

The presented study was conducted over a period of approximately 3 months, specifically during the months of April, May, and June of 2022. Around 65 employees participated, with approximately 50 of them belonging to the company's warehouse. This diverse sample allowed for a comprehensive approach, enabling the acquisition of valuable and representative insights into various aspects of the work environment and the activities carried out by the warehouse employees.

Prior to proposing solutions, it was essential to conduct a diagnostic assessment of the current situation and ascertain whether the employees agreed with the proposed improvements. However, it was equally important to identify the main challenges they were facing. This initial step allowed for a comprehensive understanding of the existing issues and provided valuable insights into the specific difficulties encountered by the employees. By involving the employees in this process, their perspectives were considered, fostering a sense of ownership and collaboration towards finding effective solutions.

4.2. Improvement Proposals

The whole process of developing the proposal for improvement was outlined so that at each stage all the work involved was understood and evolving according to the collection of data. From the start, the important thing was to determine the picking times for the boats chosen from Line A, B, C and D, as well as the distances covered by the "picker", and the consequent losses of time during each pick. Within each line there is a set of boats, where there is a greater production of one or more boat models, in the case of Line A, the 505CAB model, in Line B, the 675CR, S53 and D65 models, in Line C, the 705PH model, and in Line D, the 805CR and D77 models.

It was also important to understand if the stations were really distinct at the raw material level or if there were parts that were common, and therefore, through an Excel file it was possible to understand between the stations of each line, the line A with line A, and the line B with line B and so on until the line D boats, the parts or raw material that were common, with the purpose of avoiding repetition or excess stock in the warehouse and this way, the idea of creating a common area with the common parts to the boat stations emerged. Given the common parts mentioned, it was determined how ideal or advantageous the new layout outlined would be and where each station would best fit. However, the upholstery station, being a higher volume raw material, and with a large amount stored it was decided to put a dedicated area for it, since there are people outlined to do this work and thus this station is concentrated in a more facilitated location to improve flows. As one of the company's interests is to move the carpentry shop to another facility, it provides a new area and of interest to the allocation of raw material, providing a better and cleaner flow between aisles.

4.3. Results discussion

The new layout proposed can be observed in Figure 2. To understand its effectiveness, or the possible reduction of times in the picking process by station, this being the most viable process, because a layout by line loses advantage when comparing

the various references of materials used by the products of the four lines, and consequent repetition and existence of several locations of the same raw material.

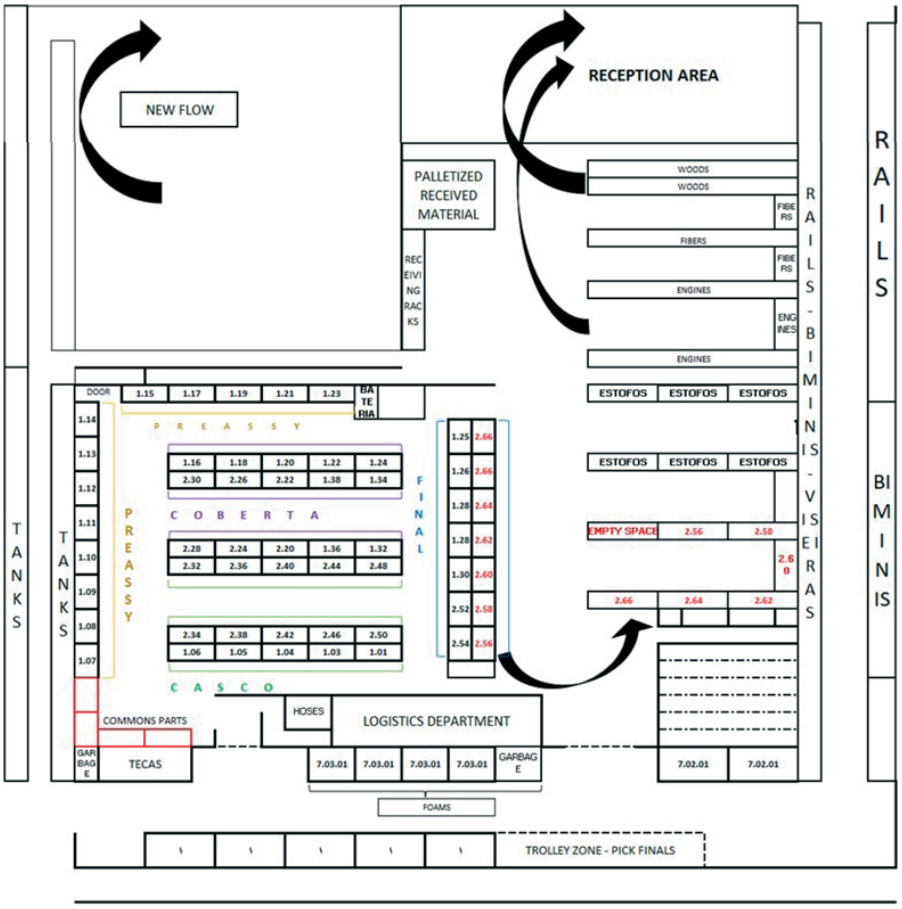

Figure 2. Proposed new layout

Table 1. Times in minutes

	Times (min.)			
Lines	**A**	**B**	**C**	**D**
Average	85,9	111,8	85,6	197,6
Standard Deviation	15,7	24,0	5,3	1,1

Table 2. Distances in meters

	Distances (m)			
Lines	**A**	**B**	**C**	**D**
Average	1405	2291,5	1120	2485
Standard Deviation	515	1,5	360	325

Once the averages and standard deviation were calculated, to better solve the new layout calculations the speed calculation of meter/minute was added, to understand depending on the new distances made how many minutes it takes the employee to pick from each station, table 3.

Table 3. Speed meter per minute

Lines	**A**	**B**	**C**	**D**
Average time (in min.)	85,9	111,8	85,6	197,6
Average distance	1405	2291,5	1120	2485
Speed (m/min.)	16,3	20,5	13,1	12,6

According to the values presented, the sum of the distances covered in the new layout by one employee started, through measurements made, and displacements calculated separately, such as from inside the warehouse to the outside to collect material (rails, biminis or visors), and in order to better highlight the discrepancies of the updated values, a calculation of percentages of variation/reduction of values (time and distance) was used (Eq. (1)), proving that the impact through the change to the new layout is really significant, because the values of time and distance of picking are reduced, while improving the flow, warehouse size and a reorganization of raw material more aligned with the objectives of the company, making even possible a consequent increase in production.

$$Layout\ change\ impact = \frac{(V_2 - V_1)}{V_1} \times 100\% \quad (1)$$

V_2 – New value; V_1 – Previous Value

The *Pre-Assy, Pick*, *Tecas* (placement of acrylics on the floor of the boat that emit wood) and *Final* designations correspond to stations, being one of the parts assembly moments. Through the percentages shown in tables 4 and 5, we see that there is most-

ly a percentage reduction between the previous values and the new ones, that is, the total time of the new Pre-Assy is, for example, in a Line A vessel, 2.81% less than the previous time. In addition, the complexity of the processes will be less.

Table 4. Percentages of variation/reduction lines A and B with the new layout

	Line A - Model 505CAB		**Line B - Model S53**	
In %	**Times**	**Distances**	**Times**	**Distances**
Pre-Assy	-2,8	-34,6	-21,5	-41,9
Pick	-32,3	-40,9	-38,1	-54,7
Tecas	0%	0%	-2,4	-14,3
Final	-36,9	-38,7	-51,3	-19,3

Table 5. Percentages of variation/reduction lines C and D with the new layout

	Line C - Model 705PH		**Line D - Model 805CR**	
In %	**Times**	**Distances**	**Times**	**Distances**
Pre-Assy	-28,4	-52,6	-45,9	-54
Pick	-16,7	-29,9	-8,2	-49,8
Tecas	0%	0%	0%	0%
Final	-37,0	-36,1	-41,6	-43,2

5. Conclusions and Future Research

This study was promoted due to the growth in production that the company experienced in a short period of time, which led to the need to maximize production capacity and, thus, optimize travel times, mainly at the level of the raw material warehouse.

Based on the results collected and analysed, it is expressive to state that the proposal to the company is satisfactory, thus fulfilling the outlined objectives, considering the reorganization of the warehouse layout by stations, promoting a better flow, reduction of time and distance and solving space problems. The application of this new organization of the raw materials warehouse is equivalent to a percentage reduction in picking time when compared to the previous layout. For example, for the *Pre-Assy* station, we observe that for line A there is a percentage reduction of 2.81% in picking time and 34.6% in the distance travelled, for the *Pick* station a percentage reduction of 32.3% in picking time and 40.9% in distance, and at the *Final* station there is a

percentage reduction of 36.9% in the picking time and 38.7% in the distance, and for all lines and stations the percentage gain is always positive. Considering the results, and as expected, the layout by stations allowed the reduction of time and distance, and as proof of this, the percentage reductions between the previous and new values of time and distance travelled, are quite expressive in certain stations.

This project and research showed that the improvement of processes at the warehouse level can be achieved through changes that do not necessarily imply a large investment by companies.

Regarding future work, and in the emergence of final ideas, it would be important for the company, at the warehouse level, to try to understand if it is possible to have another type of arrangement in terms of racks in the warehouse, that is, if there is the possibility of placing the central racks of the hull and covered station vertically, in order to create a greater use of space and consecutively create more storage availability through the addition of more racks, create cleaner flows and more direct picking paths.

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