Study, dimensioning and logistic conception of a new warehouse from a wholesaler company

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Abstract

The warehouse and its inherent activities are an extremely important element in the economic activity of a company. In former times, it was not considered aspects such as efficiency in warehouse space utilization or product handling equipment. Today, in a warehouse, there are high performance levels that are required to the firms and, consequently, the activities inherent to their warehouses.

There has been an increasing pressure for companies to deliver their products in the shortest time possible, followed with a rise more orders with little volume, but with many different SKUs. This trend in the global supply chains means that measures are being considered such as the implementation of effective strategies for various logistical operations, the adoption of inventory control to provide accuracy and the reduction of non-value added tasks, all of this combined with the use of equipment to facilitate the warehouse operations, associated with a proper warehouse design and with the implementation of information systems.

This dissertation presents an approach to the design of a new warehouse for a company in the retail of fabric rolls for uniforms and workwear, studying the most appropriate configuration for the facility, and assessing the inherent handling equipment that would help the overall logistic operation. It will also be analysed the product structure with an ABC analysis, as well as product slotting in storage locations. Additionally, it is intended to determine and analyse new logistic operations to the new warehouse.

Keywords: Warehouse design, ABC analysis, products slotting, logistics operations

1.Introduction

The trends in operational methodologies and new technologies in warehouses have been growing exponentially in recent years. In addition to this fast-paced information environment, the market demand requirements have also changed, modifying planning and operational activities within a warehouse; the planning refers to medium and long-term decisions, such as the product's storage in specific locations; operational activities refer to decisions that affect short-term activities, such as route or picking sequences (Van den Berg and Zijm, 1999; Roodbergen and Vis, 2009).

The two major decision-making categories at the strategic level, accordingly to Rouwenhorst *et al.* (2000), are related to the design of: 1) process flow and 2) storage systems. The first defines the logistic execution operations (unloading, physical checking and reception, storage, replenishment, picking, packaging and despatch); the second concerns investments in resources, storage capacity, product slotting policies, and picking strategies.

At a tactical level, issues such as the definition of picking areas, storage systems and loading and unloading dock areas, determination of MHE's (Material Handling Equipments) and the warehouse layout are discussed. Finally, it is at an operational level that the constraints defined in the previous steps will be addressed as soon as the process flows are executed. Decisions regarding the performance of the replenishment activity or the allocation of tasks to the organizational structure, for example.

Company X has significantly increased its sales volume in recent years and, alongside with this scenario, the need to implement and compose an efficient global logistics operation has raised, which will singularly result in the construction of a new warehouse for logistic system.

This project will be approached according with two main themes, where these themes will define the problem of warehouse design. An activity profiling will be accomplished with a data analysis, showing order patterns of Company X.

2.Theretical framework

In the perspective of SCM, all organizations are treated as virtual and unified entities, which include the activities of planning, product design and development, extraction, manufacturing, assembly, transportation, storage, distribution and delivery support (Tan, 2001).

As stated by Gu *et al.* (2010), the theme of warehouse design involves five major decisions:

- **Determination of the overall structure of the warehouse**, calculating the existing material flow pattern, stipulating the number of zones in storage, their function and interrelationships;

- **Measurement and warehouse sizing**, allocating the warehouse space for each zone, where the deliberated policy and inventory costs will influence this decision making;

- **Determination of the layout**, configuring it for each defined zone;

- **Selection of warehouse equipment**, determining the desired level of automation;

- **Selection of operational strategies**, designating how to operate within the warehouse.

The criteria and themes mentioned above offer a methodology perspective to be applied to the problem of warehouse design.

2.1 Warehouse design

Warehouse location decisions are fixed and cannot be modified by associated decisions, for example, customer requirements, transportation costs, among others. If the location chosen for a given installation is the result of a poorly studied decision, there may be excessive costs of transportation or inventory management incurred during the life of these warehouses. It is true that the level of efficiency related to the location of these facilities is linked to some uncertainty, particularly in terms of transport costs or inventory movements (affected by interest rates and insurance costs). Therefore, it is important and critical that the teams that plan and define these choices recognize that there is a level of uncertainty inherent in the problem of choosing a facility location (Daskin *et al.,* 2005).

Within the scope of architecture and construction of warehouses, it is necessary to create a contingency plan with safety procedures and with measures of fire prevention, a fire risk assessment should be done at the place, accordingly to the building. The existence of an escape route in the area behind shelves is often a solution neglected by companies (Richards, G., 2014).

The conceptual design of a warehouse determines the functional operations, such as the amount of storage area, what technologies will be employed, or how many orders will be processed. In the design phase of the warehouse, the focus is meeting the requirements of storage and transfer of products, as well as minimizing costs (Gu *et al.*, 2010).

There are three key topics in defining a warehouse layout: 1) aisle design; 2) allocation of products; 3) selection of the picking strategy (Gue and Meller, 2009). However, in agreement with Rouwenhorst *et al.* (2000), there is not a systematically accepted procedure for designing warehouses. In addition, there is a wide range of feasible solutions to do so.

In the design of warehouses is often considered only the storage area. However, the definition of zones and departments where different logistics operations would take place are also very important, maintaining the organization and efficiency in the overall activity of the warehouse.

Within the category of warehouse zoning, there are trade-offs in determining the total size of the warehouse and its different zones (Gu *et al.*, 2010). The problem of zoning a warehouse, referred by Koster *et al.* (2007), concerns the decision to allocate in zones the different logistic execution operations that characterize the overall warehouse activity. The relationship and interdependence between each of these zones and inherent operations is often taken into consideration. The main objective is to minimize the cost of material handling which, in many cases, translates into a linear function of the distance travelled in the warehouse.

In view of what has been said regarding the problem of warehouse design, as well as its different areas of operational logistic execution, it will be necessary to determine the best devices, equipment and infrastructures inherent to the global logistics operation of a company's activity.

To move the products in a warehouse, it is necessary to define a MHE. An MHE is any equipment that moves and stores material within a facility. For Lambert *et al.* (1998), "because an organization incurs in costs without adding value for each time a product is moved or manipulated, the primary goal of material management is to eliminate manipulation whenever possible. This includes minimizing the distance covered, bottlenecks, inventory levels, losses due to waste, mismanagement, theft and damage. "

The traditional approach to the warehouse concept consists of four main functions: receiving warehouse products, warehousing, order picking and shipping. Among these four main activities, the storage and order picking are the costliest in terms of inventory costs and labour costs (Ghiani *et al.,* 2013).

As reported by Hompel and Schmidt (2007), the overall process in a warehouse is simple and trivial, where an item is delivered locally and, because it is not consumed at the exact moment when it is received, the item will be stored until it is requested by a client. This product is subsequently removed from its place of storage and transferred to a place of despatch. Thus, it is summarily possible to describe the following macro process within a warehouse, with two vectors - inbound (unloading, receiving, storing and replenishing) and outbound processes (picking, packing and shipping).

2.2 Introduction of a WMS

In line with Dotoli *et al.* (2015), a WMS is primarily an information and technologic communication system, used for the physical control of a warehouse database and thus support daily operations within the warehouse, helping to manage inventory, warehouse locations and workforce. Its main objective is to support and monitor the movement and storage of the materials inside the warehouse and to process the associated transactions, including processes of inbound, outbound or even situations of returns. A WMS also optimizes stock storage based on real-time information, thereby obtaining a report of the current state of the warehouse.

This type of technology contributes to the reduction of complexity in information flows, to a better process coordination performance as well as to the inherent organizational structure, an increase in operational efficiency and to the company's profitability increase. Thus, it is justified the need to implement and integrate these systems into the organization structure (Alberto and Espinal, 2010).

2.3 Segmentation and product slotting

Product segmentation encompasses the following basic objectives: 1) to enable better inventory management in the warehouse; 2) efficiently locate a SKU in the warehouse; 3) infrastructures' dimensioning, necessary for the storage of products.

The ABC analysis, by the understanding of Lambert *et al.* (1998) states that the first step in this analysis will be to classify the products by sales or, preferably, by the its contribution to company's profit, because 20% of the articles may account for more than 80% of profits, as the Pareto law states. Next, the author indicates that the differences between high volume and low volume products should be checked, suggesting on how these products should be managed.

There is a strong dependence between the determination of an optimal storage strategy and the size of the warehouse and the number of SKU's per picking route (Koster *et al.*, 2007). Conforming to Bartholdi and Hackman (2014), there are two main types of storage methods: dedicated storage and shared storage. For Zhang *et al.* (2015), the dedicated storage policy is relevant in the industry, as it allows picking operators to be more familiar with SLOT's (Storage Locations) and where the products are allocated.

For Ghiani *et al.* (2013), there are three important storage policies: dedicated storage, random storage, and class-based storage. As stated by Le-Duc and Koster (2005), the class-based storage strategy divides products and SLOT's into classes, sorts them in order of decreasing frequency of orders, and then allocates products in that order to the closest locations to the point of I/O (Inbound/Outbound).

The process of warehouse design, initiated by a business plan and a supply chain strategy, usually goes through stages iteratively, because decisions taken at a given stage are conditioned by the decisions taken at a previous stage, and it is possible that the latter might be reformulated (Rushton *et al.*, 2010).

As stated by Gu *et al.* (2010), the performance evaluation should be executed during the warehouse design as well as during the specifications of the warehouse operations stage. The diagram of an approach to the warehouse design problem by Gu *et al.* (2007) was an inspiration to the methodology illustrated in the figure below, regarding the warehouse design for Company X.

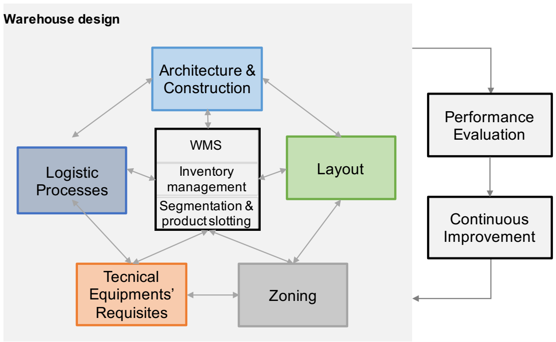


Figure 1 – Diagram with the approached themes regarding the warehouse design problem, applied to Company X project (adapted from Gu et al. (2007).)

3.Case study

The company's current warehouse has a total area of 1120 m^2 and 776 SLOT's and two I/O levelled dock points, i.e., without the aid of an equipment that compensates the height of the container of the truck with the slab of the building, being thus levelled with the outer pavement.

Currently, there are 419 different SKU's, where about 20% are rolls with 50,0 m and a diameter of 0,20 m and the remaining 336 references have 100,0m and 0,25m in diameter. These rolls are stored in bulk on the racks. These racks do not have its dimensions compatible with the dimensions of the fabric roll. In addition to this bulk storage on racks, there are certain references that are stored in a bulk-pile (set of rolls stacked under alternating layers of rolls, under a pallet.). These stacked piles occur with the denim rolls, due to its high weight and dimensions. The current warehouse aisles of Company X are obstructed, and there is lack of space to store the current references, where they often occupy the aisles areas, making it difficult for people or machines to circulate. With the reduced availability of SLOT's, it becomes impossible for Company X to increase its product portfolio if it does not change its storage space.

The present layout of the warehouse is unsuitable for a correct flow of logistic processes, where many of these logistical processes occur without taking into consideration many aspects of safety or ergonomics. In matters of information systems, the functionalities of the current ERP (Enterprise Resource Planning) are not being properly used to its fullest advantage. And without WMS, there are a lot of mistakes in storage and picking. Company X currently has 12 employees and plans to create five new jobs, anticipating the growth of the business and this new investment.

4. Implementation proposal

The warehouse sizing project of Company X begins with the design of the building already included and pre-determined in an architectural project, which has a total useful floor area of 5000 m^2, three unlevelled I/O docks and one levelled dock; it also has two floors with the administrative area.

4.1. Material handling equipment

This project has the peculiarity of not using a unitization equipment with standard dimensions. The method of storing the fabric rolls will be done through a container, that is, a cage-shaped iron structure, modelled accordingly to the needs of this business, allowing to place 39 or 25 rolls per container (depending on the type of roll). The measures considered for the container to be used for storing rolls will be the following: 1,30 m of useful height, 1,20 m width and 1,60 m depth.

Given that the project included in this work is associated with an investment venture by Company X, and due to the company's own requirements, the design of an AS/RS (automated storage and retrieval system), because this is a mechanism that implies a high investment incompatible with the company's financial structure. For the same reason, racking systems with compacted shelved goods, such as drive-in modules or modules with the use of a radio shuttle, among others, will also not be in this study.

For the existing ceilings and defined dimensions for the container, there will be four levels of storage, with the possibility of future installation of rack beams to create a fifth storage level, and rack frame should be high enough for this situation, always taking into consideration the ceiling clearance. The denim rolls would still be stored in a bulk-pile; however, they will have its location correctly marked and safe for storage.

To facilitate single access to the fabric rolls, it has been defined that they would be stored in a way that their length was parallel to the depth of the SLOT. Hence, all the rolls are visible and accessible to any operator. Having established this point, it is concluded that the forks of the transport MHE's will also be parallel to the length of the fabric rolls as well as their storage container.

The aisle width of the warehouse depends on the choice of the forklift, where the following types were studied: conventional forklift, reach truck and articulated forklift. The aisle width using a conventional forklift would be 5110,0 m, with the reach truck would be 3620,0 m and for the articulated one would be 2500,0 m; the number of SLOT's would be 1680, 2080 and 2480, respectively. Comparing the number of SLOT's that an articulated forklift inherent layout provides with the number of SLOT's available in corresponding aisles to the inherent operation of a conventional forklift, there is a gap of 840 SLOT's. This discrepancy is higher than the current Company X's SLOT's. However, the cost of an articulated forklift is three times higher than the price of the conventional forklift, and the available space also involves a greater number of racking modules, hence, more investment costs.

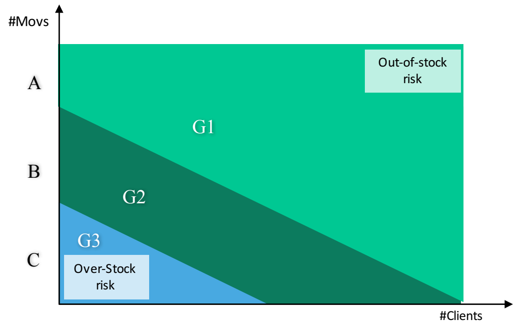
For product handling at the first storage level, it was understood that it would be necessary to use an electric pallet truck, where this equipment will support the picking process, also supported by a picking cart.

4.2 ABC Analysis

The inability to provide inbound and outbound data of products relative to anterior years of operation was essentially due to the company's lack of availability to download and provide their ERP values from previous years and regarding their confidentiality issues, too. Hence, this work deals with a one year data. Additionally, this situation is also reconciled with the fact that Company X has been showing a high sales growth, and 2015 is the most realistic future scenario, also linked with its expected economic growth. The 2015 data presents a portfolio of 419 references, where this year occurred 18505 outbound movements, where 4141053 meters of fabric were sold, acquired by 1844 different customers.

Since Company X has a very strong link to its customers' relationship, it has become a requirement to include the customer's data associated with each of the orders. Thus, in this ABC analysis two variables were included: number of orders per SKU and number of customers that buy that SKU. Thus, in an analysis with two variables and with the already categorized SKU's per movement (ABC), it has been created 7 intervals associating this type of SKU to a certain range of clients, having obtained the following estimated result.

Thus, three segmentation groups were defined, with 169 SKUs within the G1 segmentation group, 70 SKUs in the G2 segmentation group and 180 G3 products.



Graphic 1. - Estimated analysis of the groups to which a SKU may belong, with the variables "Movements" and "Clients"

4.3 Product slotting

For the methodology application of product slotting on racks, it has been assumed a conventional rack with one footprint and four storage levels in height with a total of 8 SLOT's.

Firstly, an analysis was made regarding the number of SLOT's needed to provide stock coverage for each reference, to avoid a possible stock out, ensuring the expected order cycle. Due to the unreliability of Company X's data on this topic, the following scenarios have been designed:

- Scenario 1

- SKU's G1, G2 and G3 have stock for 4, 5 and 6 months, respectively;

- In one SLOT only a SKU of group G1 may exist; only two G2 SKU's can share a SLOT; four G3 SKU's may be in the same SLOT.

- Scenario 2

- SKU's G1, G2 and G3 have stock for 4, 5 and 6 months, respectively;

- In one SLOT only a SKU of group G1 or G2 may exist, without mixing these two types of SKU's in a same SLOT; only two G2 SKU's can share a SLOT; four G3 SKU's may be in the same SLOT.

- Scenario 3

- SKU's G1, G2 and G3 have stock for 2, 3 and 4 months, respectively;

- In one SLOT only a SKU of group G1 may exist; only two G2 SKU's can share a SLOT; four G3 SKU's may be in the same SLOT.

- Scenario 4

- SKU's G1, G2 and G3 have stock for 2, 3 and 4 months, respectively;

- In one SLOT only a SKU of group G1 or G2 may exist, without mixing these two types of

SKU's in a same SLOT; only two G2 SKU's can share a SLOT; four G3 SKU's may be in the same SLOT.

The results obtained are presented in the following table, and the first scenario was the choice of Company X

# Scen	G1	G2	G3	Total SLOT's
1	593	77	70	740 SLOT's
2	593	98	108	799 SLOT's
3	351	55	59	465 SLOT's
4	351	82	100	533 SLOT's

Table 1 - Number of SLOT's per inventory management strategy defined.

To define product slotting strategy, the Affinity Analyzer software was used to determine whether to store pairs of SKU's in closed locations, if thee pairs of SKU's tend to complete orders. However, it was understood that this product slotting strategy cannot be considered, since there are very few cases, within the orders universe, where a pair of SKU's represented and completed a single order. Thus, this strategy was discarded.

Therefore, it was defined that the strategy could go through the minimum time of arrival to a SLOT by an operator using a forklift. Thus, a mapping by segmentation group was created, where the SLOT's that were more quickly reachable would be allocated to the SKU's of group G1 and the more distant SLOT's would be allocated to group G3 or products D, which represent SKU's that have not been moved for an extended period or may no longer exist in the catalogue.

To create the product slotting warehouse mappin, it was necessary to count the number of SLOT's that would be available to the future storage indicating, in each of the SLOT's (drawn in a spreadsheet) the time (in seconds) indicative of arrival and placement of a container using a forklift. Thus, it has been defined the following equation that determines the time of arrival and operation by SLOT:

$$\boldsymbol{T_{arrival}} = \left(\frac{D_{aisle}}{V_{unloaded}}\right) + \left(\frac{D_{transversal}}{V_{unloaded}}\right) + \left(\frac{h_{level}}{v_{unloaded}}\right) + \left(\frac{h_{level}}{v_{loaded}}\right) + \left(\frac{D_{aisle}}{V_{loaded}}\right) + \left(\frac{D_{transversal}}{V_{loaded}}\right) + f_s \quad (1)$$

Hence, the previous equation indicates, in each SLOT, the time $T_{arrival}$, in seconds, that it takes to an operator driving a forklift to reach that SLOT, handling the equipment forks and retrieve a container.

The equation is composed by the travelled distance along the aisle lenght D_{aisle} with a conventional forklift speed while unloaded, $V_{unloaded}$, and considering the transversal travelled distance with the aisle width, $D_{transversal}$. When it arrives to the SLOT, the forks will rise unloaded to the height h_{level} at speed $V_{unloaded}$. The forks will now descend the same height loaded with product at speed V_{loaded}. Now, the forklift will travel back to the point where it started is route, with the same distance previously travelled. To the equation, it will be added a storage factor f_s, which indicates the increment in the difficulty of removing a container as the storage level increases.

Thus, after applying this calculation to each SLOT mapped on a spreadsheet, it was possible to understand where SKU's could be stored per segmentation group. The following figure illustrates their distribution (the origin coordinate, where $T_{arrival}$ = 0, was defined in the lower left corner of the map).

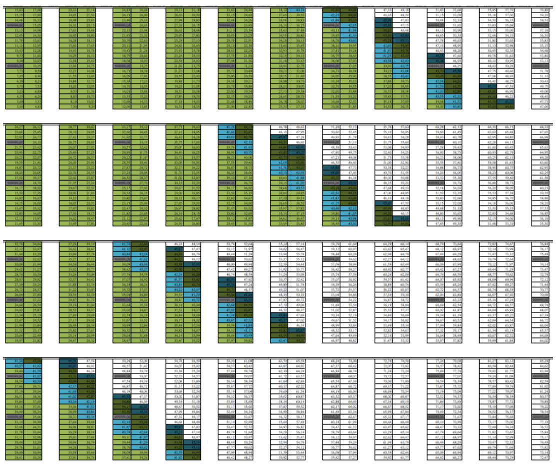


Figure 2 - Top view, per storage level, of the SKU's SLOT distribution, per segmentation group (G1 light green, G2 light blue, G3 dark green).

The number of SLOT's, by segmentation group, was defined accordingly to scenario 1 for the level of stock coverage. In addition to this number, a margin of 15% of additional SLOT's was defined. Thus, in the short or medium term, in case of a growth in the number of SKUs commercialized, these can be correctly allocated in SLOT's corresponding to its segmentation group.

4.4 Orders typology

The I/O operational area had to be sized accordingly to the average daily flows of product outputs, but it is also necessary that this operational area is prepared for atypical flow days. In this way, the same data of outbound movements used in the previous analyses will be detailed to the day. Thus, it is possible to replicate a day of operation in the future warehouse of Company X, accordingly to the daily orders. Considering only peak days, on average there is 37 orders per day distributed by 389 rolls; also, for common days, there are an average of 34 orders for 174 rolls. Although almost all the parcels are dispatched by a subcontracted transport service or by using four vehicles for internal use, to four specific routes. Regarding the daily orders, it has been established that, realistically, 10% of daily orders correspond to customers that buy products directly on site.

It is important to note that each roll will have its identification label, which includes its unique reference code and its quantity (in meters, well visible, to optimize the picking time). It is also important to highlight that all warehouse areas (storage area, I/O areas, cutting room) are marked and coded accordingly, to associate the product to that area, whether permanent or temporary product location.

4.4.1 Cutting factor

To classify the procedure in which a roll is picked, it was necessary to define a cutting factor, which stipulates that an order could be translated in an entire roll, only part of that roll (the cutting process required) or several rolls, where the last roll has been cut (also the cutting process required). The cutting factor thus allows an order line classification into three categories: "roll", "cut" or "cut + roll", dealing with the uncertainty associated with the number of rolls calculated in each order line, namely with the decimal portion of this quantity value. The results obtained were 66%, 31% and 3% of the order lines classified as "Roll", "Cut" and "Roll + Cut", respectively.

When analysing the order lines, it was also concluded that about 80% of the orders correspond to the picking of 1 to 5 order lines and that an order very often includes the shipment of 1 to 5 rolls.

4.5. Logistic execution processes

Seven main LEP's have been established, where the replenishment may take place in the storage area or in the cutting room, such as picking, where it may have to pass through the cutting room, or a roll could go straight for packing process, or even go directly to the place of dispatch, because an entire container has been ordered.

4.5.1 Offloading

The offloading process has an inherent task of preparation of the product being received, where space must be created next to the I/O docks that will receive the products, to effectively check the products and prepare them correctly accordingly to the new warehouse's informational system of Company X.

Accordingly, to the warehouse inbound fluxes data, and considering the percentage of SKU's that represent 39 or 25 rolls per container, the I/O area should be prepared with 32 empty containers, where this configuration should be repeated circa four times (3500 rolls per unloaded truck represent 127 containers).

To make this process ergonomically adjusted to the operators, it is advisable to use a roller conveyor, either manual or mechanic and with adjustable height, so that the rolls are discharged directly to the I/O area. This is necessary because the rolls arrive in bulk inside the truck's container from the supplier.

4.5.2 Physical checking and reception

Physical checking and reception is performed with a Conference List generated from the packing list associated with the truck's container, whose products will be examined. The conference list allows physical quantities checking and comparison with the quantities that are in the warehouse or pre-order location, registered in the informational system. All the checked SKU's must be identified with a bar code on the packages and individually, as this process is performed via optical reading of these bar codes labelled in each fabric roll (these bar codes will be placed in the previous process).

There are two scenarios in this LEP, within the scope of registering the quantity, in meters, that will check-in into the warehouse, where it is possible to a) enter the total number of meters assigned to a container or b) enter the individual quantity per roll, where that roll would be assigned to a container. However, the second scenario makes the LEP extremely laggard. However, it will make the picking process more effective as the WMS can easily indicate the exact location of a specific roll with the quantity (in meters) indicated on the order line.

4.5.3 Put-away

The activities related to the storage of the containers, after the conclusion of the physical checking and reception process, can be carried out in two different stock areas: conventional racking or bulk-piled, regarding the rules and storage algorithm defined in the WMS and the product slotting strategy.

The product slotting will have a relevant impact on this LEP, where it was established a function that determines the minimum travelled distance for products with rotation G1 and the maximum travelled distance for products of rotation G3, where these values are influenced by the type of MHE of transport used, accordingly.

4.5.4 Replenishment

This LEP allows you to relocate SKU's into more convenient SLOT's. Replenishment can be carried out in two different locations: a) replenishment of the closest SLOTs from SLOT's further located, in conventional racks and b) replenishment of the picking SLOT's from the cutting room stock. All replenishment movements, in conventional racks, are processed with a single loaded container and not with a single roll. However, for the cutting room, the replenishment will be done per roll. This process can be triggered manually or automatically, supported by a WMS.

4.5.5 Picking

To define the most appropriate type of picking to the operation, the values referring to the regular characteristics of an order were analysed.

A pick to order strategy will be predominant in the order preparation process ending on its dispatch. However, for the specific routes of the four vehicles belonging to Company X, which are destined to Porto, Guimarães and Braga, it will make sense to define a wave picking strategy, that is, release orders at specific times, with the different geographic routes accordingly. In this way, it is possible to avoid the time that an operator responsible for the shipping routes must wait for his orders to be picked. In this case, the method of batch picking would be a perfect fit, which would require a merge of all the order lines and after this the products would have to be sorted by its order.

However, most orders only have one order line, and each order represents only 1 to 5 rolls of fabric. Therefore, it will make sense to use the pick to order strategy for Company X's logistic operation. Still, it will make sense to apply the wave picking method, aggregating the orders by their shipment destination, sorting the orders after the picking process.

4.5.6 Packing

The fabric rolls packing process will group the items from the picking process into its respective orders. The purpose of the packaging process will be to: a) easily identify an order inside the transportation vehicle, facilitating deliveries and b) protect the fabric rolls from potential damage. Since most parcels do not fill a container or half of it, it is necessary to have material that would consolidate the items into a single order or a portion of an order, to minimize errors in the orders' delivery, by the person responsible for this activity. Thus, the packaging of an order of 1 to 5 rolls can be characterized by wrapping the item using a polypropylene tape or using a retractable plastic film; here the decision must be supported on the operator's sensitivity to the stability of the load which will be influenced by the roll's size and weight, using the packaging material accordingly.

4.5.7 Dispatch

The dispatch process of items must be done in the warehouse, using the second dock, in case of large volume orders, being this situation the most frequen. For roll transactions purchased by people onsite, the roll delivery can be done at the clients' reception area or using the first dock, if the order has high quantities and a vehicle needs to be loaded.

The beginning of this LEP occurs when the warehouse operator reads the bar code from the invoice sent by the customer and from this document a Freight Bill is generated. This document reflects the details of shipment, the items being shipped, its origin and destination, as well as the quantities to be loaded by the carrier. In addition, a delivery report is generated in WMS to record delivery completions, that is, when there is a confirmation that the order was delivered to the final customer at a specific time.

5. Final considerations and future work

Company X, which has been gaining ground on the road to leadership in the national market of the workwear segment, was born under a family context in the 1990's. The organizational structure of this company, with a great connection to certain practices and work patterns that are not easily broken, understood that the time for change had arrived, when the available space in the already inadequate warehouse did not accompany the company's current economic growth, nor would it be able to respond to the point where the company intends to reach. Transferring their industrial facilities to another location, increasing storage capacity and building a new modern space, in the image of the brand that the company intends to create, was a decision that became obvious. However, since this theme is part of a project of a consulting firm and, in addition to this, Company X being an organization with a very strong emotional culture and with very well defined limits regarding the requirements inherent to its future venture, it has been created a restricted environment to the study of alternative solutions. However, it is because of this environment that there is a naturally revealed focus on what is intended to achieve.

The present work had the fundamental intention to design a fitted solution for Company X that was aligned with its logistic requirements and with its economic growth plan for the forthcoming years.

To achieve this goal, five main pillars have been established:

- Architecture & Construction;
- *Layout*;
- Warehouse zoning;
- Technical equipment's' requisites;
- Logistic processes.

Reflecting on the work currently developed, the following points are listed for future work, inserted in this project:

- Definition of KPI's that allow the creation of a dashboard to visualize performance levels over time, where this tool would be available for the entire organizational structure of the company;

- Coordination of the revision periods of the performance analysis tools of the company's physical logistics;

-Description of a dynamic addressing strategy which, in accordance with the periodic reviews characterized by a list of available products, sets of picking orders, as well as a forecast of sales for the next period, allows to understand the costs of reallocating products, considering there is a fixed layout and a variable products' catalogue, picking activity and demand, which changes over time.

It is important to understand that a problem-solving model within the scope of warehouse design must be flexible enough when applied to real situations. Each company has its own requirements and its own way of working, with a characteristic working culture and environment. It is important to always follow the line of thought and method to operate with each organization where this model will be applied. This model should have a level of applicability and adaptability, with the intention to create value in the future operation.

6. References

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