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PROPOSAL OF AN INVENTORY CONTROL SYSTEM BASED ON THE FLOW OF MATERIALS IN A WAREHOUSE USING EXCEL/VBA

PROPOSTA DE UM SISTEMA DE CONTROLE DE ESTOQUE BASEADO NO FLUXO DE MATERIAIS DE UM GALPÃO COM O USO DE EXCEL/VBA

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ABSTRACT

Inventory management systems are indispensable for most companies since the cost of implementing robust systems, such as the Warehouse Management System (WMS), leads companies to invest a high implementation value depending on the structure that best suits their internal flow. Thus, this article sought to present the implementation of a more viable software for material management in one of the warehouses of an assembler of the two-wheeler hub in Manaus, where no warehouse system controls the flow of materials and their addressing. The Excel program developed the system using the programming language linked to Microsoft Office: Visual Basic for Applications (VBA). This system presented itself as an alternative with a more viable implementation cost than a robust system such as the WMS. In addition, the system's functioning flow was developed based on the process already done in the stock, facilitating its implementation and acceptance by the operators.

Keywords: Excel; VBA; Inventory management; WMS; System.

RESUMO

A implementação de sistemas de gerenciamento de estoque hoje é indispensável para a maioria das empresas, uma vez que o custo de implementam de sistemas robustos como o WMS (Warehouse Management System) levam as empresas a investirem um alto valor de implementação dependendo da estrutura que melhor se adeque ao fluxo interno da empresa. Com isso, o objetivo deste artigo é apresentar a implementação de um software mais viável para o gerenciamento de materiais de um dos galpões de uma montadora do polo de duas rodas em Manaus, onde não há um sistema do próprio galpão que faça o controle do fluxo dos materiais e o endereçamento dos mesmos. O sistema foi desenvolvido no programa Excel utilizando-se a linguagem de programação ligada ao Microsoft Office, o VBA (Visual Basic for Applications).

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Este sistema se apresentou como uma alternativa com o custo de implementação mais viável quando comparado a um sistema robusto como o WMS. Além disso, o fluxo de funcionamento do sistema foi desenvolvido com base no processo que já é feito no estoque, o que facilitou sua implementação e sua aceitação pelos operadores.

Palavras-chave: Excel; VBA; Gerenciamento de estoque; WMS; Sistema.

1 INTRODUCTION

Controlling the flow of materials within a warehouse is a challenge for many companies (GÄRTNER, 2012), and besides the responsibility of ensuring the safety and integrity of these materials, the warehouse sector needs to receive the materials and store and ship them to the production line.

All these steps are carried out systematically by Logistics Information Systems (LIS) systems that are subdivided into three subsystems with functions such as order management, warehouse management, and transportation management systems. Each contains information for transactional purposes and decision-support tools that are useful in planning specific activities (BALLOU, 2006 p.133).

According to Ballou (2006), assuming that this LIS is geared towards controlling the entire manufacturing infrastructure, many points where the system may not adapt or even follow the same flow as the manual process are establiwarehouse in that environment, and other means of control must be establiwarehouse not to lose the control processes of the activities of that warehouse.

Designing a system that fits a process that exists is much easier than implementing a new system with a new process. Hence, designing a system whose function is to control the movements of materials from their entry to their exit in a given warehouse and having it provide information such as the address where the material is inside the warehouse, the quantity inside the stock, and storing all the movements carried out in a database for future consultations, can be the most viable solution for a company. This is because implementing the WMS systems alone can cost up to BRL 35,000.00, not including other equipment such as collectors, printers, and switches, among others.

The WMS inventory management system interfaces with the management and exchange of information with other factory sectors. This system makes all the movements of the material balance from receiving to shipment. Thus, this system can store large volumes of information about all the materials mainly used in the production process.

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The growing need for systems capable of integrating and converting pure data into relevant information for decision-making occurs due to the increased volume of data generated within organizations (Laudon & Laudon, 2014). According to Meiryani (2020), achieving strategic business objectives in various industries is difficult without extensive use of information technology.

Netto and Moreira (2021) reported that despite using technologies, methods, and programming languages belonging to large programming ecosystems, VBA with Excel has been adopted for system development, as shown by Zulian et al. (2013), Braga and Alberte (2020), Ramadhan et al. (2020), and Xiaomin et al. (2020).

In this sense, this study sought to present the implementation of a more viable software for managing one of the warehouses of an assembler of the two-wheeler hub in Manaus, where no system in the warehouse itself controls the flow of materials.

2 LITERATURE REVIEW

2.1 Information system

For Polloni (2000), information systems can be defined as any other system that can provide information, including its own, for any activity to which it is adapted and intended. For O'Brien (2004), Information Systems are an organized set of people, hardware, software, communication networks, and data resources that collect, transform, and spread information in an organization.

According to Viana (2012, p. 408), the benefits generated by computerization have motivated consultancies in the field to develop and offer a series of fully feasible and adaptable inventory management software to companies.

Thanks to the great technologies deployed, the increasing power of information technology, and customer demands for reduced inventories, customization, and lower costs, warehouses are entering a phase where the emphasis is on handling with synchronization (GÄRTNER, 2012 p. 32).

According to O'Brien (2004), information systems can be classified into Operations Support Systems and Management Support Systems (Figure 1). The referred author also points out that they are classified in this manner to highlight the central roles that each one plays in the operations and management of a business.

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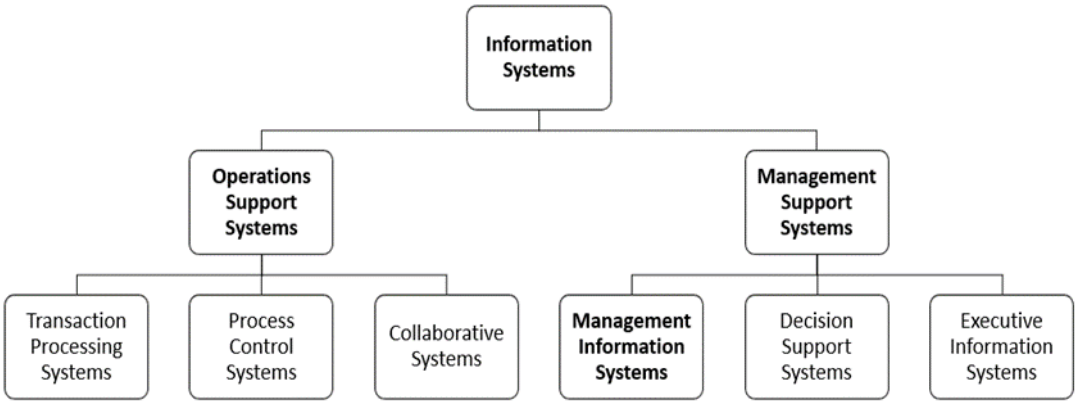
Figure 1: Classification of Information Systems



Source: O'Brien (2004)

2.1.1 Transactional information systems

The operations support system produces various information products for internal and external use, and its role is to process transactions efficiently, control industrial processes, support communications and collaboration, and update company databases. Operations support systems are transaction processing support, process control, and collaborative systems.

Transaction processing systems process in two basic ways: batch and real-time processing. In batch processing, transaction data is accumulated over a period of time and periodically processed, whereas, in real-time (or online) processing, data is processed immediately after the transaction occurs. Routinely performed information, including issuing an invoice, issuing a purchase order, and purchasing products, is usually sent to a database for storage and future consultations (O'BREIN, 2004).

2.1.2 Decision support systems

This information system offers managers interactive support for information in the decision-making process, which must be made in a complex environment involving several variables: supplier location, customer location, taxes, and politics.

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In a well-designed information system, the user is able not only to turn to it for an initial response to the decision problem but also to interact with that system to provide him with the outputs that make a practical solution to the problem possible (BALLOU, 2006 p. 143).

2.1.3 Excel and VBA

Excel is a computer program in almost all corporate computers because it is through it that most corporate reports are prepared (ZULIAN et al., 2013). It is also through it that the main systems of companies such as Oracle and SAP extract their data in formats that only Excel can load since it facilitates organizing and viewing the loaded data in a more simplified and clean way. VBA, the programming language behind the Excel program, opens an even wider range of applications, such as automating routine activities, creating more complex programs, and much more.

Rocha (2011) pointed out that VBA is a fundamental alternative for automating the use of the Excel spreadsheet, highlighting that the language allows one to create macros to perform repetitive tasks and integrate with Microsoft Office points, besides AutoCAD.

2.2 Systems for inventory management

For Graziani (2013), the main activities of a warehouse management system (WMS) are to manage the material from its receipt to its shipment and transmit this information and the balances in real-time with the addresses of these materials in a database.

Arozo (2003) stated that the WMS is responsible for managing the daily operations of the warehouse. Although there are some algorithms, their use is limited to fully actionable decisions, such as defining picking routes and defining product addressing.

According to Moura (1997), three pieces of information are important to manage an inventory regardless of the internal control used manually or systematized, which are to identify the material, address the place where the material is stored, and tell the exact quantity stored at that location.

Ballou (2006) reported that modernizing hardware in processing and storage has opened space to intensify access to enterprise information systems such as Oracle and SAP, which are the most used by most companies today.

This underlines the importance of a system that controls and creates a history of material movements and that it can provide crucial information to identify, locate and know the physical quantity of that particular location. This is because the warehouse where the initial implementation of the stock control system was done did not adopt any other type of control of the flow of materials

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that went there besides the internal dispatch system that presented to the operators the systemic balance and the number of orders paid for the production. Therefore there was no concern or record of the quantity and date the material entered the warehouse.

2.3 Warehouse activities

Physical distribution is a set of operations that relate to the flow of goods from the place of their production to their final destination and also the associated information that ensure that the goods arrive in the appropriate conditions for trade (VIEIRA, 2009).

According to BOWERSOX et al. (2006), the main concern of materials managers is to develop ways to facilitate the efficient handling of stocked materials based on the three main warehouse activities: receiving materials, stocking, and shipping.

For USAID (2012), the level of complexity of these receiving, stocking, and shipping activities vary based on the volume of products to be managed and the size of the storage facility.

The systemic control in these activities is very similar to each other. However, it is necessary to start correctly from the receipt of the materials, entering the primary information related to the input material or inside the warehouse to follow the flow then correctly, and there is no failure in the transfer of the information within the system. In the warehouse management process, any mistakes made in receiving, deliveries, postings, and extensions are accumulated over time (GRAZIANI, 2013 p. 40).

2.3.1 Receiving materials

This is the first stage of the warehouse; the receipt of materials consists of a “check-in” of the material information in the warehouse management system. The product is unloaded at the warehouse receiving docks, identified by code and quantity, and even with the address to where it will be allocated until its use (BALLOU, 2006).

According to Usaid (2012), the receiving data should be organized according to the dates of receipt along with the transaction reference, meaning the unique transaction number corresponding to the receipt and/or the name of the unit from which the products are received always create a record of the receipts that entered the warehouse. This is because, in cases of discrepancies, which can occur with large volumes of materials, the quantity received on the receipt or invoice is the basis for starting any inventory analysis to compare the physical with the systemic.

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For Moura (1997), receiving materials is the company's gateway, and many problems can occur at this stage until storage. These issues occur due to poor management at the company's entrance.

As seen above, a controlled receiving is crucial to continue correctly with the rest of the storage activities. The receiving control developed in the system was based on all the points seen above that are necessary to have good control of the storage of materials.

2.3.2 Material storage

Moving on to the second activity of the warehouse, material storage consists of storing all materials in their proper place, ensuring the stock organization, addressing the materials allocated there, and control over the physical inventory of these materials. It is important that all products placed on or removed from shelves, racks, or any other storage area, are properly recorded in the warehouse's filing records, an inventory control system to help manage them (USAID, 2012 p. 140).

For Graziani (2013), the activity of storing concerns the storage area and the storage method used. The capacity of items that must be stored and the storage method used to determine the size of the storage area. The author also states that in order to improve making storage more economical in relation to storage expenses, the physical arrangement must be very well elaborated in order to make all activities that involve a lot of material displacement easier; a good physical arrangement also reduces costs with equipment, space, material damage, and warehouse labor.

For Vieira (2009), the basic objective of the stock is not to let the production line lack material but also to attempt in every way to avoid the high mobilization of financial resources with this stock. An unorganized stock can be a headache for the whole company, especially the warehouse sector, since this problem leads to it having to pay extra hours for storage and remove people from other activities to organize and take inventory of items; everything can be avoided just by doing everything correctly during the entry of the material.

A stock with good levels of accuracy and occupancy per m² is essential for the company, especially in audits, since all stock has products with added values and charges that need to be tightly controlled. The lack of control of the stock can bring lasting consequences for the company.

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2.3.3 Material shipment

This is the last process of a warehouse's activity, which means that after this material shipment or payment stage, the material is no longer the responsibility of the warehouse sector and becomes the responsibility of the sector that received the material. The warehouse must proceed to the delivery of the material in an orderly manner and previously establiwarehouse a schedule, arranging for the conference and signature of receipt in the act of delivery (SILVA, 2016 p. 35).

According to BALLOU (2006), the shipping of materials consists in identifying the items requested in the orders and separating the materials that have left the stocks, which is the most labor-intensive and almost always the most labor-intensive part of the warehousing operations.

For USAID (2012), in material separating until shipping, the materials must be located, removed from inventory, and prepared to be shipped. The list of products and their respective quantities must be checked against the requested production orders to ensure the material is correctly shipped.

2.4 Stock control

Graziani (2013) reported that one of the goals of inventory management is to balance costs and establish supply plans that minimize total cost and determine the order quantity for replenishing an item in stock.

According to Usaid (2012), an inventory control system informs the warehouse when to requisition or notify the purchasing sector, how much to requisition for the purchase of materials, and how to maintain an adequate stock level to avoid shortages and overcrowding in the warehouse. To perform these controls, several points should be considered:

- Maximum and minimum stock control system;
- Maximum stock level;
- Minimum stock level;
- Safety stock level;
- Review period;
- Lead time;
- Emergency request point.

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Through these indicators, it is possible to maintain a controlled stock, keeping the level of stored materials constant, thus avoiding many problems related to line stoppage due to a lack of material or adequate physical space to store the material.

2.5 PDCA tool

According to Peinado and Graeml (2007), the PDCA cycle is another of Shewhart's outstanding contributions to quality. This procedure is so standard that it begins to be used as a benchmark for continuous quality improvement programs. The PDCA process begins to guide quality efforts.

For Slack (1997), continuous improvement produces a continuous discussion and re-discussion of the activities outlined in the intervention. The repetitive and periodic principle of continuous improvement is more concise than the PDCA cycle.

The PDCA is the reference model for the continuous improvement plans adopted by numerous organizations. It comprises four steps, whose names gave rise to the very name of the technique: Plan, Do, Check, and Act (PEINADO and GRAEML, 2007 p. 530).

- **Plan.** It is the fundamental step to define the goals one wishes to achieve. To do so, the strategic planning goals must be projected onto other plans that simulate the standard conditions of products or processes. This way, the goals will only be achieved through the methods supporting the practices and processes.
- **Do (Execution).** In this stage, the execution of everything that was analyzed and identified in the previous stage is done, generally elaborating on an improvement.
- **Check.** During this step, everything accompliwarehouse is validated, and a comparison of the plan with the final result and subsequent problems and failures that may occur along the way is possible.
- **Act (Action).** Finally, once the analysis is finiwarehouse, there is the need to act and correct the problems and divergences found and/or standardize the improvement elaborated in the process.

3 METHODOLOGY

This study was developed through a qualitative and descriptive approach involving the literature review that reports the aspects of the flow of materials and the aspects of decision-

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making with the support of information systems. The nature of the study is classified as applied research since concepts of material flows and the technological area were used to solve the problem (LOURENÇO, 2020).

The first step of the project was to seek the problem in the warehouse, and we identified the lack of internal control without a history of movements; this warehouse is located in the manufacturing area of a multinational assembler of Japanese nautical engines and motorcycles. In this company, the function of the materials control analyst is to perform activities related to the rotating inventory of warehouse items.

In the second stage, extensive bibliographic research was carried out in harmony with the object of the study through a selection of articles with searches carried out on Google Scholar and books and other theoretical references in the areas of the supply chain, inventory management systems, warehouse activities, material receipt, material storage, material shipment, and inventory control.

The third stage of the project was to select the PDCA method to establish the necessary objectives to proceed with the advance of the development. The plan was to define how the lack of a history of movements of the site would be solved so that it would be possible to analyze these materials in cyclic inventories. The second point was to elaborate on how this system enables one to improve the accuracy of the warehouse materials and finally adopt this system as more financially viable than the WMS system.

In the fourth stage, it was possible to develop the software. For this, it was essential to use the following hardware and software components: a laptop with the Windows 10 operating system, intel® core 2 GHz processor, 8GB RAM, 560 Gigabyte HD. In addition, the program was written in VBA language using Microsoft's Excel 2022 software.

In the fifth stage, a pre-test of the application was carried out to evaluate the potential of the system in terms of usability and processing of the data entered, and various site visits were made to monitor the use of the system from May 15 to May 30, 2022 during business hours.

In the sixth stage, the data were analyzed by tabulating the data to highlight the elaborated system's strengths and weaknesses. And finally, the result. Figure 2 shows the methodological and technical procedures that provided the basis for achieving the objective proposed by this study.

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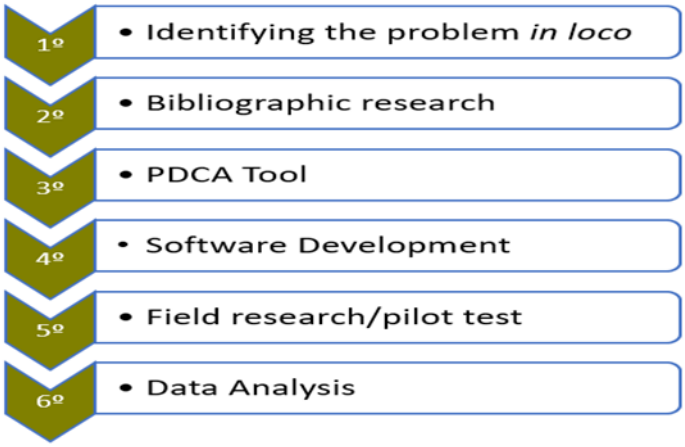
Figure 2: Flowchart of the study stages.



Source: The authors (2022)

4 PROBLEM

The idea of creating this system came after identifying *in loco* the lack of internal control of receiving and dispatching materials in the warehouse of an assembling company of the two-wheeler hub located in Manaus (Amazonas State, Brazil), operating for 52 years in the industrial hub. Previously there was no other control if not the billing process of the company that is done in a proprietary system that depends on the following sectors to perform the process of pointing to discount the balance of the warehouse system. The lack of this activity of pointing by the following sectors generated a lack of information and accuracy of the stock.

The lack of control in the warehouse is one of the big problems that generate line stoppages in the factories, and the lack of information for storage activities: receiving, stocking, and shipping generate even more difficult for the sector that is responsible for managing and purchasing them

At this point, the opportunity was identified to implement a system based on Visual Basic for Applications programming language for inventory control since other warehouses have the same difficulties by not having a WMS system implemented due to the high cost of implementation.

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The lack of an address for the received material generates many problems for the warehousing process and the other sectors, production, and planning. Given the high volume of materials that pass through the warehouse, the control of quickly locating a material is essential to the entire production process chain.

Manually entering 20-digit codes consumed much of the warehouse operators' time performing the material handling processes. To overcome this time sink in the process of entering the data into the developed system, a barcode system was developed; hence, it is no longer necessary for the operator to type, only to read barcodes that contain the necessary information to complete the entry of information into the system.

5 ANALYSES OF RESULTS

Upon analyzing the study data, it was possible to make stock predictions and quantify through the history of receipt of material from the warehouse studied using the developed system. Therefore, it was possible to control what physically enters the warehouse and compare it with the ERP system (Oracle). Furthermore, there was no way to address the material inside the warehouse. Today, it is possible to address the material by warehouse, island, pallet columns, and box in this order, which made it easier to locate the material and optimize the process of separating the materials for shipping. The shipping of the materials became easier to control after relating the materials in the warehouse to the BOM (Bill of Material), which is nothing more than the structure of the final product, in order to control the output of these materials with the order information for the production line.

Furthermore, finally, the system has made the rotating inventory process easier through the information collected from the receipt to the expedition of the material, which makes the analysis have more precise information and thus a faster and more correct result.

Figure 3 shows the workflow with and without the implemented system, and we can see that key processes were added that previously did not exist: "Stocking and addressing of the material in the warehouse."

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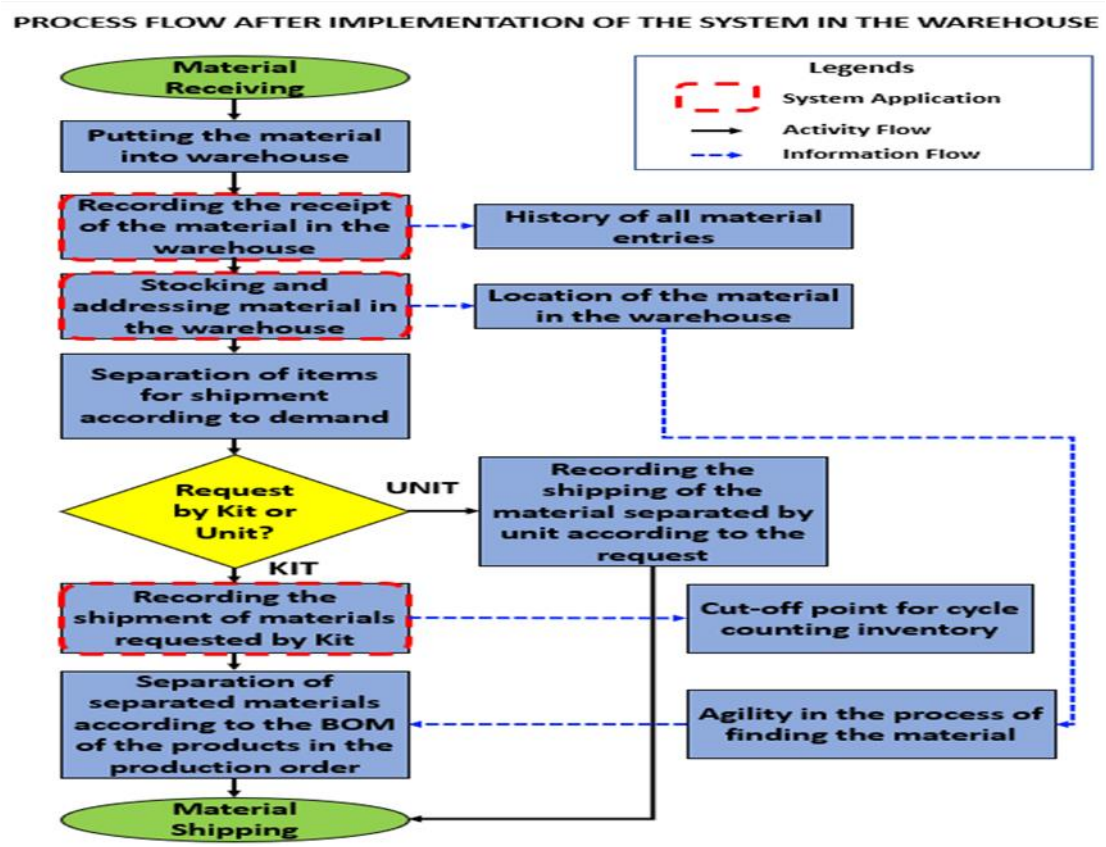
Figure 3: Process flow after implementing the system implementation.



Source: The authors

5.1 Systems and their functionalities

From the information obtained in the data collection stage, it was possible to plan and execute the programming of the system and provide it with information. The program comprises a single interface with four functionality options, referring to the fields: Reception, Payment (kit), Payment (unt), and Notice of Breakage.

When the “Receiving” option is selected, the warehouse manager inputs the information with the help of a scanner that reads the barcodes containing the information needed to enter the material into stock. Material ID Code (Part Number), Quantity, and Address include this information. After this process, the system enters the balance of the item in the system.

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When one selects the “Payment (KIT)” option, the system registers the movement in the history and discounts the balance from the materials that make up the BOM of the product that will be produced.

When the “Payment (UNT)” option is selected, the system registers the movement in the history and discounts the balance from the material ordered separately by the production sector.

When the “Breakage Notice” option is selected, the system registers the movement in the history and discounts the material balance, which refers to replacing defective material for production.

6 CONCLUSION

This study sought to investigate to what extent the Excel/VBA software contemplates possibilities of improvement for the control of the flow of materials within a warehouse, seeking to improve its control and accuracy of the materials under its responsibility.

Our findings led us to conclude that there was an improvement in inventory accuracy since it began to control the entire process of internal activities of the stock. When performing the cyclical inventory analysis, an improvement in the analysis of materials was also observed, given that the number of relevant information increased and became more accurate, especially concerning the shipping of materials. With this, it became easier to visualize the remaining stock balance in the warehouse and provide more attention to the other processes of storage and receipt.

After implementing the system, the control of the flow of materials was created at the same time as the flow of activity in the warehouse, helping maintain better control of the material correctly going to the production sector. In addition, the novel system made it possible and easier to trace the material inside the warehouse with the addressing applied right after storing it. This improvement has provided the stock with greater accuracy of its items and organization by addressing.

The application of this system, which is similar to the WMS, provided a cost reduction for the warehouse sector. The WMS software costs BRL 85,050.82, while the developed system costs BRL 8,676.29, representing 10.20% of the cost that would have to implement the WMS. Notably, considering that user logins and collectors are required to implement the WMS, and all of this is multiplied by the number of users who will have access to the system; hence, the cost of everything

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that has been presented so far is zero. Just with the proper training of employees, as it would have in implementing the WMS, it is enough for inventory control to work the way it should.

The system that showed according to the operators usability is straightforward and practical. Thus, the system proposed here represents a useful tool to help control the flow of materials in a company.

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