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Optimizing inventory control with the ABC method for a metalworking industrial maintenance company

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Abstract. The inventory control and design of a warehouse in the metal-mechanical company in southern Tamaulipas aims to optimize the inventory control and planning process in a metal-mechanical industrial maintenance services company, applying a non-experimental, transversal, quantitative, and qualitative descriptive approach and purposeful, with the ABC inventory classification method, which is obtained by carrying out a diagnosis of the company's inventory control, categorization of materials based on their rotation of use through a Pareto analysis, analysis of the rotation of type A, B, and C materials, respectively and establishing safety stocks, finally making the proposal of new policies for inventory control as well as physical distribution in the warehouse according to the ABC classification.

Keywords: Optimization, inventory control, warehouse, ABC Method

Article Info

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1 Introduction

In a metalworking industrial maintenance company in the Southern Zone of the State of Tamaulipas, where customer service and the quality of the work performed are fundamentally the company's mission, and are also the differentiator in the market, it is of utmost importance to have the appropriate inventory promptly to carry out the services it offers efficiently.

The company seeks to ensure the rotation of items optimally and efficiently; however, it does not have an inventory management system that guarantees ideal rotation under automated control and supervision of a responsible person, applying the best control techniques to increase the company's growth rates and reduce costs caused by the lack of adequate inventory control.

This research aims to optimize the inventory control and planning process in a metalworking industrial maintenance company using the ABC inventory model to classification method, which is obtained by performing a diagnosis of the company's inventory control, categorizing the materials based on their rotation of use through a Pareto analysis, using an optimization model and analyzing the rotation of type A materials and establishing safety stocks and finally proposing new policies for inventory control as well as warehouse distribution according to the ABC classification.

In this work, inventory control optimization was carried out applying a non-experimental, transversal, and propositional descriptive quantitative and qualitative approach, considering the current process for reviewing inventory control, identifying the degree of reliability of the information through a methodological process of analysis of the current situation, first with a general diagnosis through an Ishikawa diagram (cause and effect), to identify areas of opportunity, subsequently, the inventory classification was carried out with the ABC method, where the Pareto tool was applied to determine the importance of each material, equipment, tool or spare part of the universe that the company uses.

Optimizing inventory control is relevant in time management when having the material and spare parts at the right time for the provision of services, as well as to keep the equipment and tools in good condition and easily identified, saving time in the organization of the elements that maintenance companies require to carry out their work.

2 Theoretical Framework

2.1 Inventory

Inventories consist of a list in valued order of a company's items that help supply its warehouses and goods involved in the commercial or productive process (Fernández, 2018). Objectives of maintaining an adequate inventory include a) reducing risks by protecting the company's safety stock, b) reducing costs by projecting the company's acquisitions and production more efficiently, c) reducing the differences between supply and demand of the products they handle, d) reducing distribution costs by being able to schedule transportation.

Inventory management involves continuous control of the mechanisms necessary for the production of products or services, as well as the relationship with supply providers, says Valenzuela et al. (2024), such is the case of the warehouse department of this industrial maintenance company, where the entries of articles are not precisely specified, which in turn leads to a negative impact on the company at an overall level. This problem is present in the company's financial situation since it causes a high loss rate of money and, above all, incorrect decision-making.

However, the design of inventory control must consider the requirements of the company's business and limitations, such as those studied by Kuo and Jian (2023): inventory space and the number of changes.

Lack of proper inventory control can cost a company dearly. On the one hand, the lack of an item, in this case, a spare part or consumable, can stop the maintenance service delivery process; in this case, not delivering the product or providing the service in the established time can lead to the loss of customers and, consequently, markets. (Omid Abdolazimi et al., 2021).

According to Tejero (2008), inventory control is the system that allows for the management of a warehouse's stock, whether incoming, in-process, or outgoing. The ultimate goal is cost optimization and achieving the best use of stock.

2.2 Inventory control techniques

ABC (Always Better Control) analysis: It is based on the cost of the items in the store and its principle is that a small number of items consumes a large amount of resources and vice versa (Singh, 2022). ABC analysis is one of the most efficient and widely used inventory classification techniques in organizations. (Torabi et al., 2012). The stock, life cycle, and product sales are the main characteristics that must be considered when executing logistics planning, and it is essential to study them using the 80-20 curve (Ballou, 2004).

VED Analysis: Material can be classified based on another parameter: “Criticality”, which implies the value of the material to achieve the organization’s objectives. (Reyes, 2009)

ABC VED Matrix Analysis: The results of ABC and VED analysis are combined and further categorized.

SDE Analysis: When item shortages are common, items are categorized based on availability and are as follows: scarce, hard to obtain, and readily available.

FSN Analysis: Here, items are classified according to quantity and consumption rate as fast-moving items.

Good inventory management allows for optimizing times from the preparation of tools, materials, and equipment for the execution of a job to the optimization of costs of not having the inventory ready for the provision of industrial maintenance services.

In their work, Becerra et al. (2022) conclude how supply chains manage sustainability through quantitative inventory management models, which are gaining more and more attention due to the alignment of industries with sustainable development goals. Still in inventory management, Nikolopoulou and Ierapetritou (2012) make the environmental approach possible with the application of recycling, reusing, remanufacturing, renewing, repairing, and reducing.

2.3 **Warehouse**

A warehouse is a place where materials, tools, equipment, and raw materials remain until the client, in this case, the employees of the industrial maintenance company, require an item. The warehouse has become one of the most significant parts of the logistics chain since with a well-organized warehouse the necessary materials can be supplied immediately (Sánchez, 2017).

On the other hand, Pierre (2018) states that warehouses must be organized, orderly, and clean spaces that allow employees to identify which elements are necessary for their work.

A good distribution in the warehouse will make the logistics processes more efficient, due to the maximum optimization of its spaces. In their work, Hualpa and Suárez (2018) carry out a review of warehouse sizing among which linear programming techniques, dynamic programming, heuristic methods, mathematical models, and computational tools predominate and they apply a mathematical model where they involve production planning.

Similarly, warehouse design is explained in five major decisions: structure, dimension, internal layout, choice of equipment, and operating strategies in which production policies intervene in terms of material supply (Jinxiang, 2010).

3 Material and Methods

The research methodology used in this work is non-experimental, transversal, descriptive, and purposeful. The sample taken is the purchase records, reports of services rendered, payment vouchers, and inventory records of material, equipment, and tools in the period from January to April 2024. The phases of the applied methodology can be observed in Figure 1. For the collection and analysis of information, checklists and documentary analysis were used.

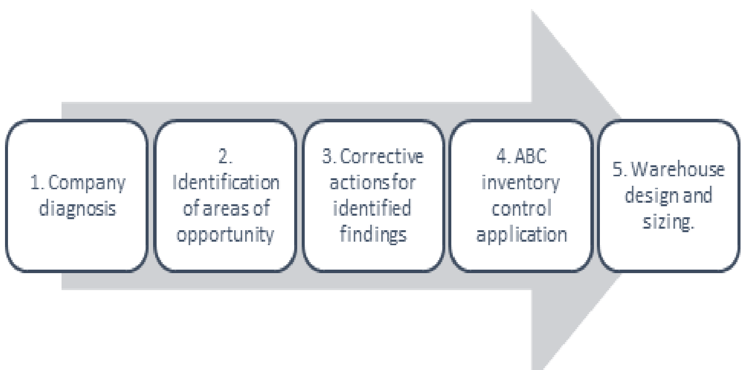

Fig. 1. Research Methodology
Source : Adaptation from Pérez et al. (2018)

From a qualitative point of view, the degree of importance that each product has for the company is evaluated through essentiality criteria. This evaluation can be carried out using expert criteria or methods that allow a hierarchical order to be obtained.

The assignment of the comprehensive selection involves the following steps: first, determine the quantitative weighting factors that express the importance relative to the organization of the lines classified in each of the zones, according to the selected base parameters.

The weighting factors are represented through the following nomenclature:

F_{ij}: weighting factor of classification zone *i* for base parameter *j* (1)

Where: *i*: A, B, C. *j*: 1, 2,..., *n*, *n*: number of base parameters.

The weighting factors are distributed precisely as shown in Table 1.

Table 1. Classification factors by classification zones

Parameter	Zones		
	A	B	C
1	FA_1	FB_1	FC_1
2	FA_2	FB~~2~~	FC_2
3	FA_3	FB_3	FC_3
n	FA_n	FB_n	FC_n

Source: Parada , O (2009)

Due to the characteristics and importance of each classification area, the weighting factors must meet the following restriction: $FA_j > FB_j > FC_j$

Secondly, determine the total score (Pk) of each product k through the sum of the weighting factors, according to the classification zone in each parameter.

$$Pk = \sum_{i.i}^{n} Fi,j \, * \, W \tag{2}$$

Where: W: Decision coefficient of the term. *i*: A, B, C. *j*: 1,... , *n*. *k*: 1,..., *m*. *m*: quantity of products. W = 1 if F_{ij} belongs to the vector V_k. W = 0 if F_{ij} does not belong to the V_k vector. V_k: classification vector of product *k*.

For the product taken as an example in the first step of the procedure, the classification vector would be: V = (A,B,C).

Thirdly, formulate the decision rule for assigning the integral selective code. Thus, the maximum and minimum values that Pk can adopt for each product are defined. According to the restriction posed, the maximum and minimum values are determined by the following relationships.

$$Vmax = \sum_{i=1}^{n} FAj \tag{3}$$

$$Vmin = \sum_{i=1}^{n} FCj \tag{4}$$

Where: Vmax: sum of the weighting factors of zone A for each base parameter *j*. Vmin: sum of the weighting factors of zone *C* for each base parameter *j*. *n*: number of base parameters.

Vmax and Vmin define an interval (Vmax, Vmin) that is divided into three classes in order to establish the integral selective code. The amplitude of each class will be given by the value of the quotient shown below:

$$ACL = (Vmax - Vmin)/3$$

For the assignment of the unique selective code, the following decision rule is proposed: Comprehensive selective code A: products that meet the following condition are classified as A: (Vmax – ACL) < Pk < Vmax. Comprehensive selective code B: products that meet the following condition are classified as B: (Vmin + ACL) < Pk < (Vmax – ACL). Comprehensive selective code C: products that meet the following condition are classified as C: $Vmin \leq Pk \leq (Vmin + ACL)$.

4 Results

According to the methodology, the results are described in the following 5 sections.

1. Company diagnosis.

Using an Ishikawa diagram, the causes and effects of inventory management were analyzed to determine the root cause of warehouse problems. Figure 2 presents the analysis performed using the fish diagram.

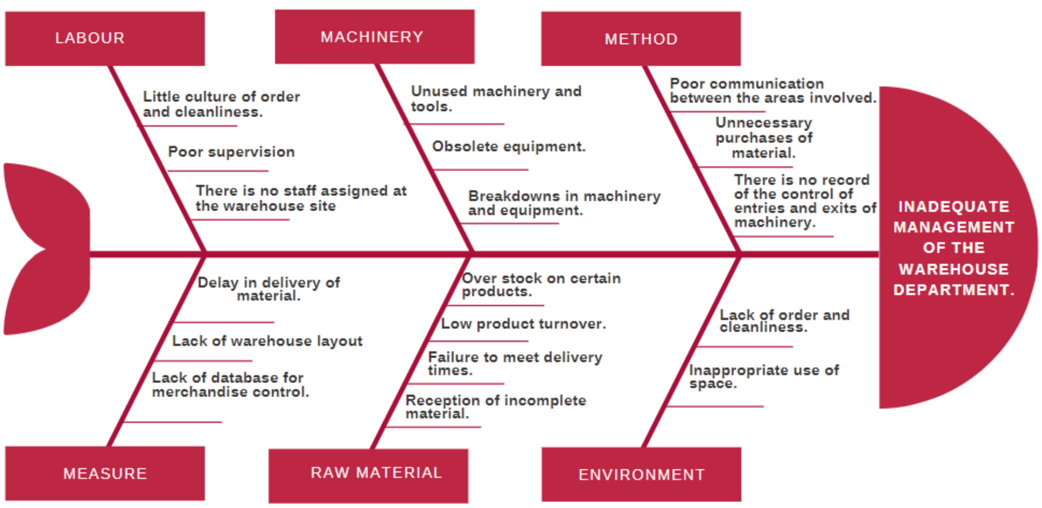

Fig. 2. Ishikawa diagram
Source: Own elaboration.

2. Identification of areas of opportunity in the warehouse and inventory control.

As seen in Figure 2, the identified areas of opportunity that are directly related to adequate warehouse management and inventory control focus on the method and measurement, for which corrective actions were proposed.

3. Corrective actions for identified findings.

   a) Create a database to keep track of the warehouse's entries and exits. One of the main strategies implemented was designing and creating a database of 466 items. For its development, help was requested from company engineers, as well as a review of documents and warehouse records. Together, the database was designed using dynamic tables to create an automated system that could record the movements of each of the items available in the warehouse.
   b) Take inventory of what is in the warehouse and discard all material that does not meet the optimal conditions for use. The listing of this catalog consists of a total of 466 items, including harnesses, suede gloves, nuts, electrodes, welding machines, polishers, tweezers, particle guards, cutting discs and various more that the company has to achieve the manufacturing services requested by the client, however, for an effective search these items are classified into several types, which correspond to the following: tool, equipment, minor equipment, consumable

material, manufacturing material, paints/solvents, cleaning equipment, in which the quantities that each one comprises are observed in Figure 3 below.

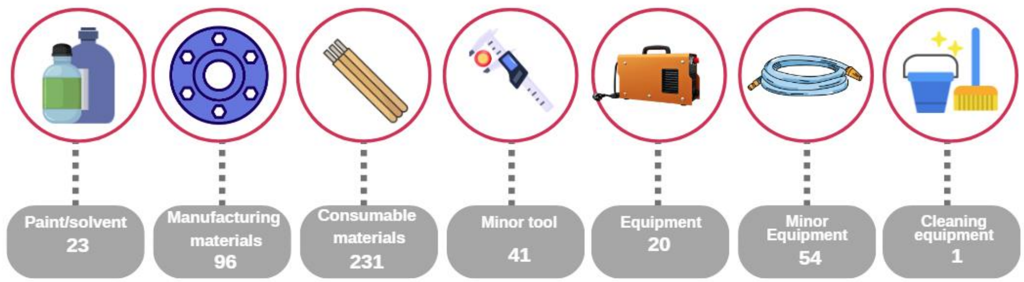

Fig. 3. Inventory
Source: Own elaboration

The second section of the database includes entries and exits, whereby selecting the code and description included in the catalog, the necessary information is automatically obtained and the entry or exit is only recorded manually. These recorded movements are added or subtracted as appropriate to keep the quantity of existing merchandise up to date to make the most appropriate decision. Through this section, various data are filtered to create graphs and compare results in a very efficient way. Figure 4 shows the structure of the database built with the company records and the analysis of four months of work.

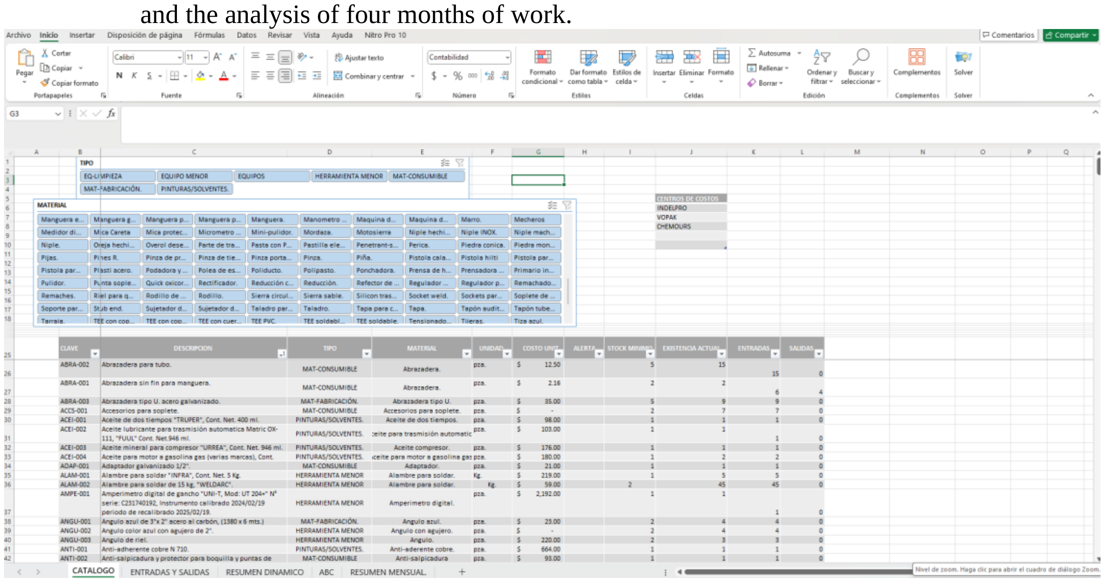

Fig. 4. Database structure for inventory control
Source: Own elaboration

c) Apply ABC methodology to establish the relationship with the purchase, reception, and control of inventories. According to what was established, the ABC inventory control methodology was implemented based on the degree of rotation of the articles. The ABC method is defined in the segmentation of articles taking into consideration the demand for each of the articles based on this criterion, and the application is executed appropriately. The articles analyzed are all those that during the period from January to April have been considered to be in greatest demand by operators; these articles are of the consumable material type. Therefore, only those with constant rotation were considered to evaluate which articles stand out in the warehouse to prioritize their control, maintaining a special interest in them, since they are undoubtedly essential to successfully achieve the services required by external clients. The items with the highest turnover in the company were graphed, which can be seen in Figure 5, and the ABC inventory classification can be seen in Table 1. The Pareto diagram can also be seen in Figure 6.

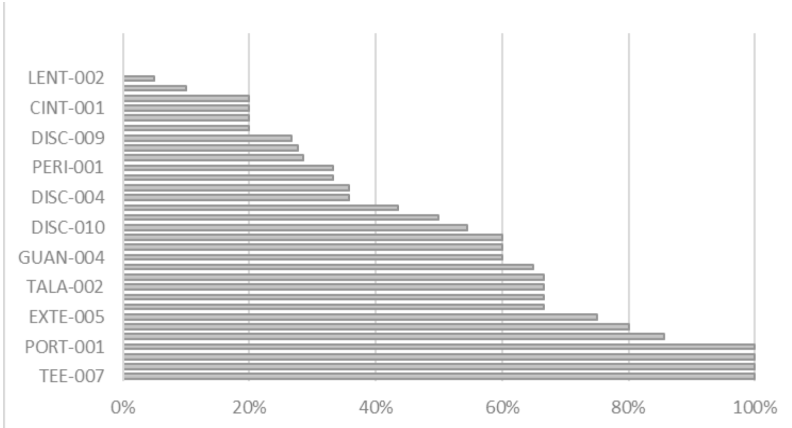

Fig. 5. Articles with the highest turnover
Source: Own elaboration

Table 1. ABC inventory control based on turnover

Group	No. Products	Inventory (%)	Rotation (%)
A	**12**	**40**	**79.5**
B	**10**	**33**	**14.8**
C	**8**	**27**	**5.7**
	30	**100**	**100**

Source: Own elaboration.

For each item, the classification was obtained from the application of the ABC method, according to the conventional procedure for each of the selected base parameters. This will allow you to have a selective code A, B or C, following the ranges established to delimit each of the zones of classification.
d) Carry out the distribution of the area, establishing defined places for each item and improving the traffic inside. Once the items with the highest turnover were identified, the appropriate distribution within the warehouse was carried out, which can be seen in Figure 7.
e) Provide feedback to the database to keep the warehouse control up to date.
f) Establish cleaning programs to raise awareness among interested parties, maintaining a culture of order and cleanliness.

4. Application of ABC inventory control

By applying the ABC method for inventory control, the Pareto diagram was obtained, which establishes that 80% of the results come from 20% of the actions. This project was segmented into parts in a way that helps identify which items have the highest turnover.

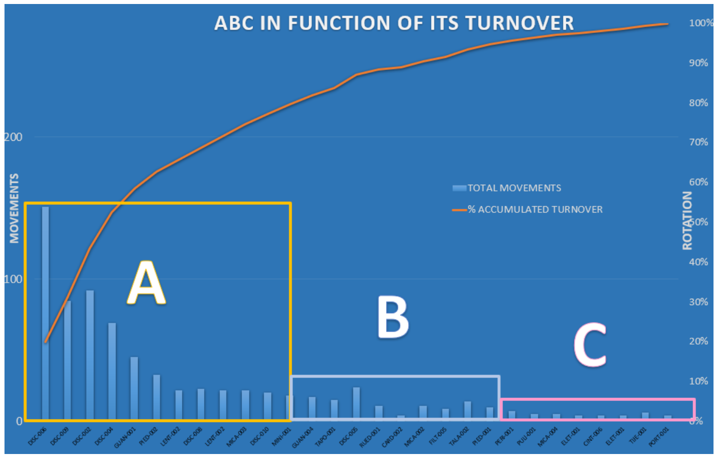

Fig. 6. Pareto chart
Source: Own elaboration

The results obtained from the analysis show that; 20% of the articles represent 78.7% of the total turnover, 30% of the articles represent 15.4% of the total turnover and 50% of the articles represent 5.8% of the total turnover.

5. Warehouse design and sizing

One of the main areas of opportunity identified in the company was to improve the flow of item rotation. This involved a series of activities and actions implemented to distribute items strategically, maximizing the use of available warehouse space and considering the layout of the shelves.

Through visualization and analysis of constant merchandise rotations, the structure was created to make the most of the dimensions of the area and use the shelves in the best possible way.

Taking the premises of the ABC inventory management systems as a starting point, the items are classified as shown in Figure 7.

An improvement in space can also be observed, with the move inside the warehouse area. To make the most of the shelves and space inside, a place is reestablished for each of the elements, where items are established as any element with the greatest relevance at the time of manufacturing in the production area.

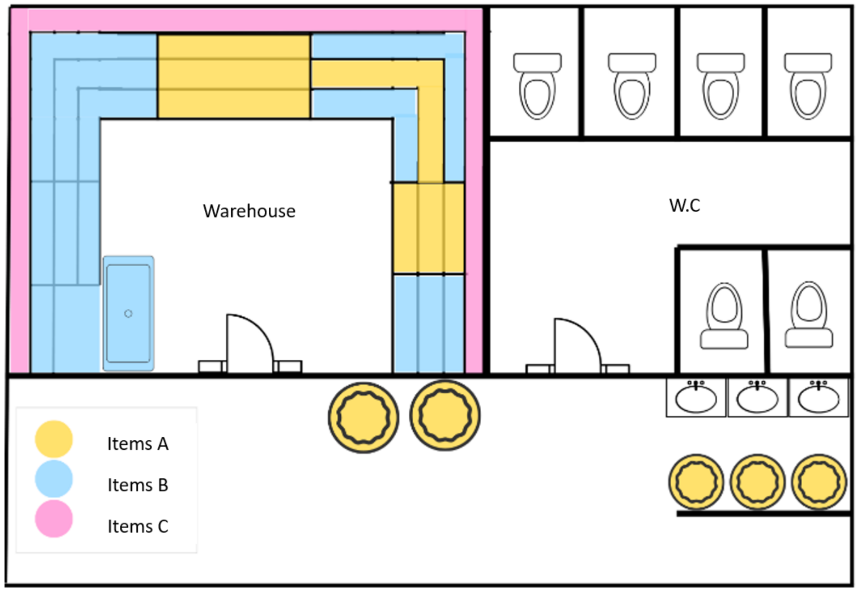

Fig. 7. Warehouse distribution of inventory
Source: Own elaboration

These items are under safeguard given that, although they do not have a high unit cost, it is vitally important to maintain priority control since it is possible to carry out manufacturing activities with them. These items are classified as Consumable Material.

On the other hand, B items are considered the items with the lowest turnover, including Manufacturing Materials, Paints/Solvents, and Minor Tools.

On the other hand, there are C items positioned on the top shelf where they were strategically placed to avoid obstructing the search and transfer with equipment that is not essential for production but is convenient to have available; these items are minor equipment.

With the implementation of the database, efficient control was achieved during the current period. Statistics show a reduction in the acquisition of unnecessary merchandise, managing to maintain records and inventory with sufficient stock for the requirements of the work.

By accessing the information, it can be compared that the acquisitions of merchandise have been significantly reduced, the results shown are the product of the ABC analysis in which the rotation of merchandise is analyzed.

5 Conclusions

The diagnosis of the current inventory control situation allowed us to identify the areas that needed attention: processes and measurement. The analysis reinforced the design and management of the inventory control systems in the warehouse area of the metalworking industrial maintenance company, where from this, it was possible to obtain valuable information for decision-making, since it is urged to carry out continuous monitoring, the design of the database of the 466 items that they manage in their inventory was an efficient tool, likewise, it is proposed that once the database is fed with everything existing in the company, a verification of the effectiveness of inventory control is carried out.

By using ABC inventory control systems, it was possible to strategically classify the items under the aspects of the ABC method referring to products in category A as those with the highest degree of rotation, B as the lowest degree, and those of type C as very low demand, demonstrating that the method is effective when searching for items.

The application of ABC inventories allows for constant updating, to give priority to items with greater turnover or demand, so that they are kept under control to avoid a shortage of the same. With the implementation of this inventory control system, downtime has been reduced by 18%, and the number of maintenance tasks carried out in the time committed to the client has also increased, just as the structural redesign inside the warehouse revolutionized a significant change in the transfer and flow of merchandise.

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