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Materials Management Practices for Reducing Warehouse Inventory Levels in A Metallurgical Industry: A Case Study

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ABSTRACT
In the current scenario of intense competitiveness among companies, the inventory management area is currently perceived as strategic for achieving global goals within organizations, given that inventories represent a significant portion of the assets and capital invested in materials. Therefore, the investigation aims to explore the application of inventory management tools in a metallurgical industry, seeking to understand how the control of material inventory levels is conducted, while evaluating performance indicators and achieved outcomes. For the development of this study, analyses of Warehouse indicators were conducted, comparing the scenario before and after the implementation of material management methodologies. The general objective of this study is to investigate the application of inventory management systems in a steel processing industry in the State of Ceará. Through the completion of this work, improvements in the area's results were observed, including: reduction in inventory values, increase in material availability levels for the factory, and enhancement in inventory accuracy.

Keywords*: Inventory; Accuracy; Warehouse; Management tools.*

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I. INTRODUCTION

Currently, the Brazilian metallurgical industry has been facing challenging economic situations, as the country's economic crisis has led to a reduction in demand for investments in infrastructure and both public and private construction projects. Therefore, to maintain competitiveness in the market, organizations are increasingly seeking to implement management tools and new process technologies to achieve economic and financial equilibrium.

In the face of increasing international competition in the flat steel and derivatives segment, Brazilian companies have sought ways to reduce costs and strengthen profit margins. Consequently, there has been a constant and growing need for comprehensive knowledge about the activities undertaken, aligning with the best management practices to enhance productivity and performance.

In this context, productive metallurgical operations have sought tools to better manage materials, ensuring greater product availability for both internal and external customers, planning their inputs and outputs, and minimizing the high capital invested in inventory.

Thus, inventory management has gained greater emphasis, and studies focused on materials management have become more important and applicable in the metal-mechanical sector. Based on this, the analytical method employed involved making comparisons between the performance indicators of the warehouse that underwent the research, examining the highlighted improvements in results following the implementation of materials control and management tools.

The general objective of this study is to investigate the application of an inventory management system in a steel process industry in the state of Ceará, exemplifying how simple materials management tools can result in significant gains for the company. The hypothesis evaluated was the improvement of inventory performance indicators after the implementation of the management system in the Warehouse sector.

Four specific objectives were determined: to discuss logistics in general, focusing on materials and the Warehouse; to demonstrate the importance of inventory management with emphasis on management tools,

exemplifying significant changes in results with real numbers; to research how inventory levels are controlled in the studied company; and to evaluate inventory management performance after the implementation of the inventory control system, analyzing changes in inventory, service level, accuracy, and material classification.

The article was structured into five sections, beginning with the introduction, followed by theoretical foundation, methodology, case study, and concluding remarks.

II. MATERIAL AND METHODS

The research can be classified within a qualitative approach. Qualitative research, according to Ciribelli (2003), occurs when data only make sense through secondary logical treatment [1].

According to Gaither and Frazier (2012), in this type of research, data and information are obtained through unstructured interviews, observation, analysis of historical company data, as well as bibliographic research contributing to the resolution of the studied problem, which is the case of the present work [2].

This research, in terms of objectives, is characterized as descriptive, since the collected and analyzed data allowed describing the applied inventory management practices in the warehouse of a metallurgical industry.

Regarding procedures, research can be defined, according to Gil (2002), into two groups of delineation: those that use so-called paper sources and those whose data are provided by individuals. In the first group, bibliographic research and documentary research are found. In the second group, there are experimental research, survey, case study, and action research [3].

This research is classified as a case study, analyzing the activities and techniques used in inventory management in the warehouse of a metallurgical industry.

Yin (2015, cited in Arruda; Silva; Luz, 2021, p. 06), states that:

> The most used sources of evidence in case study research are: documentary, records in archives, interviews, direct observations, participant observation, and physical artifacts. The documentary data collection technique is one in which documentary information is relevant to all case study topics. This information can take various forms and should be the object of explicit data collection plans [4].

The study is based on research with participants in the researched phenomenon, analysis of primary data provided by the studied company, and observations made by the author at the site of the phenomenon. Questions were addressed about motivations for the implementation of inventory management tools, objectives, necessary resources, results obtained, etc. Research data were collected through the ERP (Enterprise Resource Planning) used to manage inventory, daily tracking spreadsheets, and management reports.

III. THEORETICAL FRAMEWORK

In this research, topics related to the field of materials management will be addressed, such as logistics, inventory management, types of inventory, and inventory management tools. These themes will serve as the foundation for the discussed case study.

3.1 General Aspects of Logistics

Logistics encompasses the supply of materials and components, the movement and control of products, support for the sales effort of final products, up to the placement of the finished product for the consumer. The field consists of two main subsystems of activities: Materials Management and Physical Distribution, each involving the control of movement and demand-supply coordination.

Dias (2010) identifies the following functions as logistic activities: Purchasing; Scheduling deliveries to the factory; Transportation; Inventory control; Material storage; Forecasting material needs; Administration of distribution centers; Planning of distribution centers; Customer service planning [5].

According to Ballou (2001), logistics has taken responsibility for the availability of raw material stocks, semi-finished products, and finished products, at the time and place where they are required and at the lowest possible cost. Thus, it is through logistical processes that inputs reach factories and products are distributed to consumers [6].

Initially, companies used, for example, the warehouse as a facility for significant manual processing of material entry and exit, without more accurate controls. However, with the increase in business competition and consequent reduction in profit margins, this approach becomes impractical. Ferreira et al. (2016, p. 88) assert that "[...] organizations use the warehousing process to meet customer needs; thus, warehousing is a strategy of the organization in response to the service level defined with its market [7]."

3.2 Inventory Management

Inventory management is essentially the comprehensive planning of how to control materials within an organization, working precisely on what the company needs for specific storage areas, aiming to maintain a balance between stock and consumption.

Dias (2010) presents the function of inventory management as maximizing the efficiency of sales feedback and adjusting production planning and scheduling [5].

Today, inventory management is considered fundamental to organizational success. It is through an inventory process that one can take advantage of space utilization, operational resource utilization, personnel time optimization, and order picking processes.

According to Fleury et al. (2007), inventory management is viewed, from an integrated perspective, as the foundation of the supply chain along with other logistics process activities. Good inventory management depends on four important factors: when to order, how much to order, how much safety stock to maintain, and where to store [8].

Inventory management plays a crucial role in a company's profitability. Inventories tie up capital that could be invested in other ways, divert funds from other potential uses, and carry the same cost of capital as any other investment project. Therefore, through inventory level management, one must identify how much to purchase to avoid excess inventory or material shortages.

Aveni (2019) explains that a company's inventories are assets that seek to achieve a balance between the essential elements for storage over a certain period to fulfill orders, maintain continuity in the production process, and minimize asset downtime in the business cycle. Inventories also require management to define adequate and satisfactory levels of materials capable of meeting customer needs [9].

According to Pozo (2017), inventory control is aimed at establishing the various levels of materials and products that the company needs to maintain. Having a plan for all inventory control activities is essential for reducing the company's operational costs [10].

3.2.1 Inventory and Inventory Management Tools

Inventory refers to materials and supplies that a company or institution maintains, whether for sale or to provide inputs or supplies for the production process. "Inventories are idle resources with economic value, which represent an investment aimed at enhancing production activities to be served to customers [11]."

Inventory is inevitable in the context of an organization. The way it is stored and managed can either increase the company's profitability or cause losses. Therefore, it is very important for the materials manager to actively participate in inventory administration and control.

On one hand, inventories are costly, often representing a considerable amount of capital, and they are also risky because items held in inventory can deteriorate, become obsolete, or simply get lost, in addition to occupying space. On the other hand, they provide some security in a complex and uncertain demand environment.

The function of inventories is to meet the company's demand through a supply process, which occurs through the acquisition of products. Inventory accuracy arises when demand processes and supply processes are not in agreement; at a certain point, there is a lack of synchronization between them, which generates the need for inventories. This can occur due to various reasons, such as economic factors that prevent supply and demand processes from being synchronized [12].

Inventory management conducted without planning or with deficiencies in its cycles through improper physical arrangement or problems in equipment availability negatively impacts company results, especially in product delivery times or in fierce competition with competitors. On the other hand, well-designed and correctly executed inventory management in all its stages can surprise the organization with positive effects [13].

In the face of an ambiguous scenario, there are several tools available to manage inventories that assist in control, work, and decision-making by those responsible for management.

3.2.2 ABC Analysis

According to Hong (2010), the ABC analysis is one of the oldest and most well-known methods applied in industries. It is based on the reasoning of the Pareto diagram, where not all items have the same importance, and attention should be given to the most significant ones. Thus, 80% of the inventory capital is employed in only 20% of the stocked items [14].

According to Cervone (2009), to adopt the ABC analysis in inventory management, products should be classified into three categories: Class A: 20% of the products account for 80% of the inventory value; Class B: 30% of the products account for 15% of the inventory value; Class C: 50% of the products account for 5% of the inventory value [15].

For Dias (2010), this is a method of great importance in categorizing inventory to identify those items that warrant attention and adequate treatment regarding their management [5].

3.2.3 Inventory Turnover

Inventory turnover, also known as stock turnover, is a measure of the relationship between annual consumption and the average stock of a product. In essence, it indicates how many times during a specific period the inventory has been replenished.

According to Dias (2010), the evaluation criterion for inventory turnover is determined by the company's inventory policy. The author emphasizes the importance of considering several key factors, such as the availability of capital for inventory investment, which determines the standard turnover rate. It is not advisable to apply the same turnover rates to materials with different prices. Utilizing the ABC classification as a basis is recommended [5].

Based on the company's policy, production programs, and sales forecasts, it is essential to determine turnover that meets the needs at the lowest total cost. Establishing a frequency for comparing standard turnover with actual turnover is crucial.

3.2.4 Service Level

As per Martins and Alt (2004), the service level is the indicator that measures how effectively inventory has met the users' requests. Thus, the higher the number of requests fulfilled, the higher the service level. The result is obtained by dividing the number of requests fulfilled by the total number of requests made, with the outcome displayed as a percentage.

Maintaining material availability in inventory is of paramount importance, as the absence of a particular item can directly interfere with a company's process continuity and consequently lead to significant losses in operational results.

3.2.5 Replenishment Lead Time: Reorder Point

According to Hong (2010), the objective of the reorder point is to initiate the replenishment process with sufficient time to prevent material shortages. It is the time elapsed from the identification that stock needs replenishing to the actual arrival of the material from the company's warehouse. When the stock reaches a level known as the reorder point, a purchase order is triggered [14].

The reorder point level helps control the additional quantity of stock needed as protection against demand fluctuations and replenishment lead time. Thus, the likelihood of material shortage is reduced.

Dias (2010) describes that replenishment lead time can be divided into three parts: Order issuance: the time taken from the issuance of the purchase order until it reaches the supplier. Order preparation: the time taken from the supplier manufacturing the products, sorting the materials, issuing invoices, until they are ready to be transported. Transportation: the time taken from the supplier's departure until the company receives the ordered materials [5].

Dias (2010) states that the reorder point can be determined by the following formula [5]:

RP = CM + LT + MinSt

Where:

RP = reorder point

LT = lead time

CM = average monthly consumption

MinSt = minimum stock

IV. ANALYTICAL REPORT OF RESULTS

The study was conducted at the warehouse of a large-scale company in the metallurgical sector. Analyses were conducted through interviews with department members and also by examining key performance indicators.

Due to the rapid expansion of operations, the necessity for improved process management, and significant lack of control over the capital invested in material procurement, the senior management of the company identified the need to restructure the warehouse area. This led to the creation of a department called Materials Management, tasked with the planning and strategic management of storage, movement, demand, and inventory levels within the warehouse.

4.1 Analysis and Interviews Conducted

According to the company's materials manager, the reason behind implementing inventory management tools within the group was the fact that inventories represent a significant portion of the company's assets, and in the case of raw materials, they account for an average of 90% of the cost of finished products. According to the interviewees, the lack of inventory control tools led to several operational difficulties, such as:

a) Excessively large stock quantities;

b) Unavailability of important items for productive operations;
c) High capital investment in inventory;
d) High discrepancies and stock deviations;
e) Difficulty in accommodating materials in the warehouse;
f) Inadequate physical space for storage.

The department manager emphasized that for better material management performance, it was necessary to utilize and acquire certain resources. These included investment in a good ERP system, implementation of material planning tools, team training, implementation of processes for cycle counting, improvement in material identification, improvement in warehouse layout, and acquisition of storage and handling equipment such as pallet racks and forklifts.

To initiate a new inventory management model, in addition to utilizing ERP software, it was essential to establish a dedicated work cell responsible for material planning. Subsequently, inventory control activities were subdivided into warehouse processes and material planning processes.

As evidenced during the research, the leadership of the department has direct involvement in the planning and control routines of inventory materials. Weekly meetings involving operational and tactical level employees of the department occur. The focus of these meetings is the discussion and explanation of performance indicators, such as inventory value and coverage, material availability or service level, accuracy, discrepancies in physical receipts, purchase values, and material consumption. Action plans and the effectiveness of actions already taken for indicators where targets were not met are also discussed.

The realization and evaluation of results can be better appreciated through the performance indicators presented in Table 1. The numbers represent average annual values based on data following the implementation of the new department and tools.

Table 1 - Area Performance Indicators

	Average Year 1	**Average Year 2**	**Average Year 3**
Value in Inventory (R$)	R$ 11,192,887.13	R$ 9,135,447.32	R$ 8,647,219.26
Material Availability	92.39%	94.25%	95.08%
Accuracy	91.48%	98.82%	99.95%
Inventory Coverage (months)	6.97	6.14	5.98
Inventory Turnover (times per year)	1.72	1.95	2.01
Items Received with Physical Discrepancies	1.75%	0.92%	0.52%

Source: Spreadsheet of Indicators from the Materials/Storehouse Department

V. DISCUSSION AND CONCLUSION

The analysis of the implementation of inventory management tools was conducted by examining several performance indicators of the Storehouse, observing the evolution of results over the years. Additionally, an interview was conducted with the materials manager, from which relevant information about the significant changes resulting from improved inventory control was extracted.

The case study achieved its objectives as it investigated how inventory levels were controlled and evaluated performance after the implementation of materials management tools. Year after year, the indices have shown improved results.

Analyzing Table 1, improvements in all indicators are observed. Comparing the third year with the first year after the implementation of management methodologies, the main results were as follows: inventory values reduced by 22%. Material availability for factory prompt response increased by 2%. Inventory accuracy increased by 9%. Inventory turnover increased by 16%.

Furthermore, it was possible to identify that the materials management continually encourages its team to achieve increasingly ambitious goals and that the company sees inventories as a factor of great importance for the effectiveness of the organization as a whole.

A very relevant point is that the studied company holds high inventory values for items that have no movement, have no turnover. This group of materials without turnover in inventory for over a year represents approximately 47% of the total inventory value. Some of these items are components of machinery already obsolete in the factory, while others are strategic and critical items for operations.

It is suggested that the company take measures to reduce inventory values of materials that have not had turnover for over a year. It is important to classify these items to understand which ones are actually part of the strategy to keep in inventory even without movement (items for critical equipment maintenance) and which ones are no longer useful (obsolete). From this point, plans should be drawn up to reduce inventory values.

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