OPTIMIZING SPARE PARTS INVENTORY AND WAREHOUSE LAYOUT AT PT XYZ USING ABC ANALYSIS

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Abstract:

Background: Spare parts warehouse management in the manufacturing industry often faces challenges owing to unstructured organization, where high-value and low-value items are frequently mixed. This condition is prevalent at PT XYZ, a refined sugar company, leading to operational inefficiencies and prolonged search times owing to the lack of a clear classification system.
Purpose: This study aims to analyze inventory control at PT XYZ using Activity-Based Classification (ABC Analysis) to classify spare parts and design a proposed physical warehouse layout to enhance operational efficiency.
Design/methodology/approach: This research employs a quantitative descriptive approach to analyze 94 spare part items. Annual usage data were evaluated using the ABC analysis method to categorize items into A, B, and C groups based on their cumulative value. Following this classification, a proposed warehouse layout was designed to optimize spare-part placement according to their priority levels.
Results: The inventory was categorized into three groups based on cost contribution: Group A accounted for 78.8%, Group B for 15%, and Group C for 5%. The proposed layout strategically positions Group A near the warehouse entrance for rapid access, places Group B on the middle shelf, and allocates Group C to the rear area for space optimization. This systematic arrangement significantly minimizes retrieval time and mitigates the risk of damage to high-value assets in the warehouse.
Conclusion: The application of the ABC analysis at PT XYZ has proven effective in classifying 94 spare part items to optimize inventory control based on investment value. The implementation of a new systematic warehouse layout has the potential to enhance operational efficiency and reduce item retrieval time. To ensure the sustainability of the system, companies should consistently carry out warehouse restructuring, provide inventory management training for employees, and conduct periodic evaluations to ensure that inventory management remains adaptive to operational requirements.
Originality/value: The novelty of this research lies in the integration of ABC economic value analysis with systematic physical layout design, specifically within a refined sugar industry spare parts warehouse, to reduce operational costs. These results provide a guide for warehouse managers in decision-making regarding storage allocation and monitoring priorities, ultimately reducing machine downtime caused by delays in spare part availability. This strategy enables the company to optimize its working capital through more precise inventory control of Category A items.

Keywords: ABC analysis, warehouse layout, spare parts management, operational efficiency, refined sugar industry

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INTRODUCTION

Inventory management is a critical operational function in manufacturing industries because it affects production continuity and efficiency. Spare parts warehouses play a strategic role in supporting maintenance activities by ensuring material availability and reducing equipment downtime (DT). Effective and systematic spare parts management can improve operational performance, whereas poor management can cause maintenance delays, higher costs, and lower productivity (Anggreini et al. 2024). However, many companies still face challenges in managing spare parts inventories because of the absence of clear prioritization based on item value and usage frequency. This condition often leads to inefficient material handling, longer retrieval times, inventory inaccuracies, and increased risks of damage, loss, or theft, which ultimately increase operational costs (Richards, 2022; Amanda & Kirono, 2024; Emmett, 2021).

ABC Analysis is a fundamental warehouse management approach that classifies inventory into Categories A, B, and C based on value and turnover rate (Suta & Sari, 2025; Rahayu & Santoso, 2023). This method enables management to focus on items with the greatest impact on operational performance and cost (Tinamberan et al. 2025; Sumarauw, 2017). When integrated into warehouse layout design, high-priority Category A items are placed near access points, whereas Categories B and C are stored in less accessible areas to optimize space utilization (Rosyidin et al. 2026). This zoning strategy improves material flow, enhances operational efficiency, protects high-value inventory, and supports a safer and more productive working environment (Lathif et al. 2025; Rosyidin et al. 2026). Recent studies have shown that the lack of systematic inventory classification can lead to inefficient warehouse operations. At PT Pupuk Kujang Cikampek, ABC analysis improved spare parts control and supervision of critical items (Putra et al. 2024), whereas Savira and Miharja (2024) found that it enhanced inventory control by identifying materials requiring stricter oversight. Despite these benefits, PT XYZ still stores spare parts without a structured classification system, resulting in inefficient retrieval and stock inspection. Therefore, an integrated inventory classification and warehouse layout strategy is required to improve operational efficiency.

To address this critical gap, this study contributes to inventory management by integrating statistical classification with a physical warehouse layout design. While traditional literature often separates inventory control from spatial optimization, this study presents them as interconnected elements of a dynamic process. By developing a model that links procurement frequency with physical accessibility, this study highlights how operational efficiency is driven by both management and storage strategies. Furthermore, within the refined sugar industry, this study provides empirical evidence on how these integrated strategies can resolve complex material-handling challenges in manufacturing environments.

ABC analysis is widely recognized as an effective inventory classification method that categorizes items into A, B, and C groups based on their value and consumption intensity, enabling organizations to prioritize control efforts and improve inventory accuracy (Suta & ABC analysis is widely recognized as an effective inventory classification method that groups items based on their value contribution and consumption intensity, enabling organizations to prioritize inventory control and improve management effectiveness (Rahayu & Sari, 2025; Rahayu & Santoso, 2023). Previous studies have demonstrated the benefits of AI in enhancing inventory supervision, reducing holding costs and stockout risks, and supporting managerial decision-making (Putra et al. 2024; Savira & Miharja, 2024; Lahu & Sumarauw, 2017). In addition, advancements such as Warehouse Management Systems (WMS), 5S implementation, and inventory planning methods have further improved inventory accuracy and warehouse operations (Chatisa et al. 2019; Rizqillah et al. 2024). However, limited research has integrated the ABC-based inventory classification with the physical warehouse layout design. Therefore, this study combines the ABC analysis with a systematic spare parts warehouse layout optimization approach to enhance retrieval efficiency and material handling performance.

This study employs a systematic approach to improve spare parts warehouse management at PT XYZ by analyzing inventory conditions, including usage frequency, economic value, and storage practices, and using inventory transaction data to identify consumption patterns and movement intensity. ABC analysis is then applied to classify spare parts into categories A, B, and C based on their value contribution, providing a basis for inventory control. Based on the classification results, a structured warehouse layout was designed by

placing high-value and frequently used items in easily accessible locations, whereas lower-priority items were allocated to less critical areas. This layout is intended to optimize space utilization, reduce retrieval time, enhance material handling efficiency, simplify inventory inspections, and improve overall warehouse operational performance and productivity.

This study aims to improve spare parts inventory management at PT XYZ through the integration of ABC analysis and warehouse layout optimization. This study addresses the inefficiencies in inventory control and storage arrangements that lead to longer retrieval times, lower warehouse productivity, and higher operational costs. ABC analysis is used to classify spare parts according to their value contribution and usage frequency, providing a basis for aligning inventory priorities with warehouse storage locations. Given the critical importance of spare part availability in supporting maintenance activities and ensuring production continuity, the proposed approach seeks to reduce retrieval time, enhance warehouse productivity, lower operational costs, and provide practical guidance for effective spare parts warehouse management.

This study contributes to the field of operations management by providing empirical evidence of the effectiveness of integrating ABC inventory classification with warehouse layout design to improve operational efficiency. This study proposes a comprehensive framework that aligns inventory priorities with spatial planning, offering a useful reference for future research. The findings also demonstrate the value of ABC analysis as a basis for storage zone allocation, supporting efforts to reduce inefficiencies and enhance the workflow performance. Furthermore, this study provides a replicable research methodology that can be applied in similar logistics and supply chain contexts.

METHODS

This study employs a quantitative descriptive research design to systematically and objectively analyze spare parts inventory management at PT XYZ. The quantitative approach serves to characterize the inventory based on numerical data regarding usage frequency and cost contribution. The descriptive component provides a factual representation of the current warehouse conditions.

Data collection involved both primary and secondary sources of information. The primary data comprise inventory records of 94 spare part items, which were analyzed over a one-year period to capture comprehensive annual usage patterns and cost distribution. Primary data also included real-time insights from direct observations and stakeholder interviews. In addition, secondary data were obtained from company documents, including inventory reports, purchase price records, and standard operating procedures (SOPs) related to warehouse management. Additionally, a comprehensive literature review was conducted by gathering academic journals and textbooks to establish a robust theoretical foundation. This study employs a quantitative descriptive research design to systematically and objectively analyze spare parts inventory management at PT XYZ. The quantitative approach serves to characterize the inventory based on numerical data regarding usage frequency and cost contribution, while the descriptive component provides a factual representation of the current warehouse conditions.

Data were collected using a multi-method approach to ensure the validity and credibility of findings. First, a literature review and document analysis were conducted using academic references and company records, including inventory reports, purchase price data and standard operating procedures. Second, direct observations were performed in the spare parts warehouse over an eight-month period to examine inventory movements, storage practices, and material handling activities using standardized observation forms. Third, semi-structured interviews were conducted with warehouse supervisors and inventory staff selected through purposive sampling to gain deeper insights into the inventory control practices. Finally, data triangulation was applied by cross-checking the interview results with the observational findings to enhance the accuracy and reliability of the research.

The data collected were analyzed using the Activity-Based Costing (ABC) analysis method, which classifies inventory items based on their contribution to the total inventory value. ABC analysis was selected because it enables the prioritization of control efforts for high-impact items that significantly affect operational costs. The stages of ABC analysis applied in this study followed the procedure proposed by Wahyuni and Titis (2016):

1. The total usage quantity of each spare part over one year was calculated.
2. A list of purchase prices for each spare part used during the observation period was compiled.
3. The annual usage value is calculated by multiplying the usage quantity of each item by its purchase price.
4. Ranking spare parts with the highest to lowest annual usage values.
5. Calculating the cumulative value of all spare parts: The cumulative percentage of each item is determined using the following equation:

   Item cost percentage = (Item cost / total cost of all item) x 100%

6. Grouping inventory items into categories based on their cumulative percentage values.

According to Firdaus and Hadining (2023), the ABC classification categorizes inventory items based on their contribution to the total inventory value. Class A items contribute approximately 70–80% of the total inventory value, despite representing only approximately 20% of the total number of items, requiring strict monitoring and intensive control. Class B items account for approximately 15–25% of the total inventory value and 30% of the total items, necessitating a moderate level of control. Meanwhile, Class C items contribute only approximately 5–10% of the total inventory value but comprise nearly 50% of the total number of items; therefore, they require relatively minimal monitoring and control.

To ensure the reproducibility of this study, the data analysis was based on a transparent and standardized validation process. Regarding data validation, all extracted inventory records were cross-checked against physical stock counts and manual logbooks to eliminate inconsistencies between the system data and actual warehouse conditions. Furthermore, the qualitative insights derived from observations and interviews were subjected to a member-checking process, in which the summarized findings were reviewed by the warehouse supervisors to ensure that the interpretations accurately reflected the operational reality. For the classification criteria, the ABC analysis was performed based on a dual-parameter approach: annual usage frequency and total annual cost contribution. The items were classified systematically by calculating the cumulative percentage of these parameters, where 'Group A' represents high-value or high-frequency items (typically accounting for 80% of the total impact), 'Group B' represents moderate items (15%), and 'Group C' represents low-impact items (5%). By explicitly documenting these threshold percentages and the underlying calculation logic, this study provides a replicable framework that can be adapted to other manufacturing or spare parts inventory contexts.

The framework of thought in this study illustrates the logical relationship between the research variables and analytical stages. The framework begins with identifying problems in spare parts inventory management at PT XYZ, particularly unstructured storage and inefficient retrieval processes. These problems are addressed through data collection on spare part usage and cost. The data collected are then analyzed using ABC analysis to classify spare parts into categories A, B, and C based on their value. The classification results serve as the basis for developing warehouse layout recommendations that prioritize high-value and high-frequency items. Ultimately, the proposed layout is expected to reduce retrieval time, improve warehouse productivity and lower operational costs. The research framework of this study is shown in Figure 1.

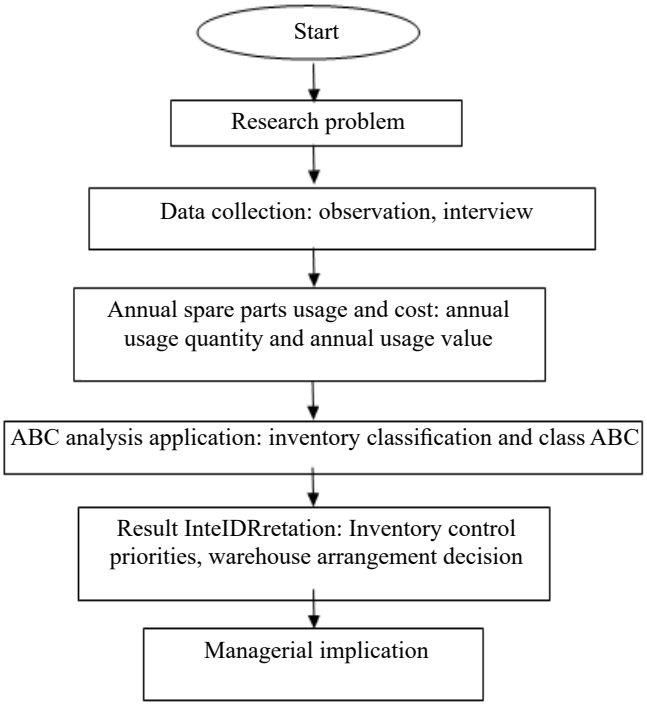


Figure 1. Framework of research

RESULTS

Data on the usage of 94 spare parts, along with the unit price of each item, was collected and analyzed over one year at the PT XYZ warehouse. For each spare part, the usage quantity and unit price were recorded. Subsequently, the usage value of each item was calculated by multiplying the quantity used by its unit-price. The items were then ranked from highest to lowest usage value in monetary terms. Subsequently, cumulative values and percentages were calculated. Based on the data processing results in Table 1, three groups of spare parts were classified using the ABC analysis, as shown in Table 2.

Table 1. Processed data of ABC classification results at PT XYZ for one year based on cost (IDR/ unit) and usage (unit/ year)

Item Name	Usage (unit/year)	Cost (IDR/unit)	Total Investment (IDR)	Cummulative	% cummulative	Category
Mckenzie Screw Conveyor, Shaft Connector	5	32,000,000	160,000,000	160,000,000	48. 188	A
Coupling	44	630,000	27,720,000	187,720,000	56. 54	A
Nut, Lock, -, 11/4Inch, Pvc	162	121,000	19,602,000	207,322,000	62. 44	A
BallValve, 1/2Inch, Manual, Jis10k, Cs	11	1,550,000	17,050,000	224,372,000	67. 58	A
Bearing, Spherical Roller, -	2	6,335,000	12,670,000	237,042,000	71. 39	A
Bolt, Hex, -, M18X70, Sus	18	620,300	11,165,400	248,207,400	74. 75	A
Elgi Compressor, Banjo, Pn 000959931	8	955,500	7,644,000	255,851,400	77. 06	A
Cutting Wheel, 1Mm, 4Inch	400	14,500	5,800,000	261,651,400	78. 80	A
Air Cylinder	3	1,850,000	5,550,000	267,201,400	80. 48	B
Coupling	44	125,000	5,500,000	272,701,400	82. 13	B
Bolt, Hex, M12X30, Cs	355	11,300	4,011,500	276,712,900	83. 34	B
Ball Valve, 3/4 Inch, Manual	3	1,080,000	3,240,000	279,952,900	84. 32	B
Sirca Actuator, Repair Kit	2	1,500,000	3,000,000	282,952,900	85. 22	B
Elgi Compressor, Oil Filter, Pn	4	650,000	2,600,000	285,552,900	86. 00	B
Bolt, Hex, M16X70	34	69,000	2,346,000	287,898,900	86. 71	B
Bolt, Sleeve Anchor, M16X	210	9,500	1,995,000	289,893,900	87. 31	B
Bearing, Deep Groove Ball	4	491,000	1,964,000	291,857,900	87. 90	B
Butterfly Valve	3	590,000	1,770,000	293,627,900	88. 43	B
Chain, Double, Rs80, Rivet Pin	2	840,000	1,680,000	295,307,900	88. 94	B
Bolt, Hex, M10X50	24	70,000	1,680,000	296,987,900	89. 45	B
Cable Lug, Ring, 16Mm,	28	59,000	1,652,000	298,639,900	89. 94	B
Air Torque Actuator, Repair	3	508,000	1,524,000	300,163,900	90.40	B
Bearing, Deep Groove Ball	4	357,000	1,428,000	301,591,900	90.83	B
Bolt, Hex, 3/4X4Inch	86	16,000	1,376,000	302,967,900	91.25	B
Padlock, 50Mm	10	130,900	1,309,000	304,276,900	91.64	B
V-Belt, C, 86	7	175,000	1,225,000	305,501,900	92.01	B
Gear, Worm, 37X75X268.7	9	125,000	1,125,000	306,626,900	92.35	B
Lamp, Bulb Led, 19W	16	69,000	1,104,000	307,730,900	92. 68	B
Bearing, Adapter	2	460,000	920,000	308,650,900	92. 96	B
Seal, Gasket, Ansi 600	4	230,000	920,000	309,570,900	93. 24	B
Bearing, Deep Groove Ball	3	298,000	894,000	310,464,900	93. 51	B
Lamp, Halogen Spotlight, 80	7	125,000	875,000	311,339,900	93. 77	B
Bolt, Hex, M24X	20	41,250	825,000	312,164,900	94. 02	B
Ball Valve, 1Inch, Manual, Jis	3	270,000	810,000	312,974,900	94. 26	B
Bolt, Hex, M16X110, Cs	66	2000	1 922,000	313,766,900	94.50	B
Plug Electricity	3	238,000	714,000	314,480,900	94.71	B
Auxiliary Contact, 1no/1nc	11	65,000	715,000	315,195,900	94.93	B

Table 1. Processed data of ABC classification results at PT XYZ for one year based on cost (IDR/ unit) and usage (unit/ year) (continue)

Item Name	Usage (unit/year)	Cost (IDR/unit)	Total Investment (IDR)	Cummulative	% cummulative	Category
Seal, Gasket, Ansi600, 3	5	145,000	725,000	315,920,900	95. 15	C
Shaft Coupling, Flex, Fcl160	2	345,000	690,000	316,610,900	95. 36	C
Bearing, Deep Groove Ball	2	345,000,	690,000	317,300,900	95. 56	C
Cable Ties, 4.8X300Mm	10	63,900	639,000	317,939,900	95. 76	C
Bearing, Deep Groove Ball	3	215,000	645,000	318,584,900	95. 95	C
Fan, Axial, 8Inch	2	310,500	621,000	319,205,900	96. 14	C
Bearing, Seal, Dh515	4	157,900	631,600	319,837,500	96. 33	C
Bolt, Hex, M12X60	41	15,000	615,000	320,452,500,	96. 51	C
Cable Lug, Ring, 10Mm,	23	26,400	607,200	321,059,700	96. 70	C
Emergency Stop Push Button, Twist, 22Mm,	3	201,000	603,000	321,662,700	96. 88	C
Bearing, Radial Insert	3	175,000	525,000	322,187,700	97. 04	C
Hinge, Lathe	60	8,250	495,000	322,682,700	97. 18	C
Socket Electricity, 3-Phase	2	238,000	476,000	323,158,700	97. 33	C
Bolt, Sleeve Anchor, M8X65	40	11,500	460,000	323,618,700	97. 47	C
Lamp, Halogen Plusline, 500W	11	40,000	440,000	324,058,700	97. 60	C
Bolt, Sleeve Anchor, M10X50	80	5,500	440,000	324,498,700	97. 73	C
Pliers, Circlip, 7Inch, Chrome	2	214,200	428,400	324,927,100	97. 86	C
Brush, Paint, 2Inch	31	13,000	403,000	325,330,100	97. 98	C
Scrapper	30	13,500	405,000	325,735,100	98. 10	C
Bearing, Deep Groove Ball	4	102,000	408,000, 00	326,143,100	98. 23	C
Mcb, 3p, 40A	2	202,200	404,400	326,547,500	98. 35	C
Cable Ties, -, 4.8X200Mm	10	35,000	350,000,	326,897,500	98. 45	C
Mcb, 1p, 2a	9	37,700	339,300	327,236,800	98. 56	C
Seal, Gasket, Ansi600, 2	4	85,000	340,000	327,576,800	98. 66	C
Mackenzie Boiler, Screw	4	80,000	320,000	327,896,800	98. 76	C
Flexible Hose, Braided, 1Inch	2	150,000	300,000	328,196,800	98. 85	C
Bolt, Hex,12X80	16	19,000	304,000	328,500,800	98. 94	C
Bearing, Deep Groove Ball, 6007, 2z	2	125,000	250,000	328,750,800	99. 01	C
Bearing, Deep Groove Ball, - , 6206	3	85,000	255,000	329,005,800	99. 09	C
Gear, Worm Wheel	6	44,000	264,000	329,269,800	99. 17	C
Regulator, Lpg	3	80,000	240,000	329,509,800	99. 24	C
Scrapper	12	20,000	240,000	329,749,800	99. 31	C
Seal, Oil, Pneumatic Seal	8	25,000,-	200,000	329,949,800	99. 37	C
Pliers,Combination	4	50,000	200,000	330,149,800	99. 43	C
Auxiliary Contact, 1no/1nc	3	65,000	195,000	330,344,800	99. 49	C
Pliers,Combination	1	183,900	183,00	330,528,700	99. 55	C
Bearing, Seal, Dh515	1	157,800	157,800	330,686,500	99.60	C
Bearing, Deep Groove Ball,	2	85,000	170,000	330,856,500	99.65	C
Bolt, Hex, -, M12X100, Sus	12	13,500	162,000	331,018,500	99.70	C
Bearing, Deep Groove Ball,	3	45,000	135,000	331,153,500	99.74	C
Bearing, Deep Groove Ball	2	53,000	106,000	331,259,500	99. 77	C
Battery, Aaa	6	15,600	93,600	331,353,100	99. 80	C
Bushing, 16X25X25 Mm	5	18,000	90,000	331,443,100	99. 82	C
Socket, 1/2Inch, Plain, Aw, Pvc	33	2,100	69,300	331,512,400	99. 84	C
Battery, Aa	6	9,500	57,000	331,569,400	99. 86	C
Battery, 6lr61, 9V	3	25,000	75,000	331,644,400	99. 88	C

Table 1. Processed data of ABC classification results at PT XYZ for one year based on cost (IDR/ unit) and usage (unit/ year) (continue)

Item Name	Usage (unit/year)	Cost (IDR/unit)	Total Investment (IDR)	Cummulative	% cummulative	Category
Lamp, Indicator, 22 Mm	2	37,000	74,000	331,718,400	99. 91	C
Washer, Flat, M10	30	2,000	60,000	331,778,400	99. 92	C
Pliers, Circlip, 7Inch	2	38,000	76,000	331,854,400	99. 95	C
Bolt, Hex, M12X100	11	5,000	55,000	331,909,400	99. 96	C
Lamp, Indicator, 22Mm	2	15,000	30,000	331,939,400	99. 97	C
Seal, Oil,45X65X5	1	25,000	25,000	331,964,400	99. 98	C
Solder Wire	2	9,500	19,000	331,983,400	99. 99	C
Bolt, U, 2Inch, Gi	3	5,000	15,000	331,998,400	99. 99	C
Lamp, Indicator, 22Mm	2	5,800	11,600	332,010,000	99. 99	C
Bolt, U, 11/2Inch	3	3,300	9,900	332,019,900	100. 00	C
Solder Wire	1	9,500	9,500	332,029,400	100. 00	C
			Total	332,029,400		

Table 2. Classification of spare parts using ABC analysis based on quantity and cost at PT XYZ for one year

Group	Number of spare parts	Investment value (IDR)	Investment Value per Category (%)
A	8	261,651,400	78.80
B	29	53,544,500	16.13
C	57	16,833,500	5.06
Total	94	332,029,400	100

The empirical findings from the inventory analysis at PT XYZ reveal a classic Pareto distribution of spare part values. As detailed in Table 2, the inventory is divided into three distinct categories based on investment significance. Category A represents the most critical group, comprising only 8 items yet accounting for a substantial 78.80% of the total inventory cost (IDR 261,651,400). Despite their low quantity, these items are the financial backbone of the warehouse. These findings align with the principles established by Liu and Ma (2020), emphasizing that the "critical few" require the most rigorous management and intensive oversight. Category B includes 29 items, representing 16.13% of the total value (IDR 53,544,500), while Category C consists of 57 items contributing a mere 5.06% (IDR 16,833,500). This distribution confirms that at PT XYZ, nearly 80% of the capital is tied up in less than 10% of the spare parts variety.

Building on the ABC classification, a redesigned warehouse layout was developed (Figure 2) to bridge the gap between financial value and physical accessibility. The proposed layout utilizes a strategic zoning strategy (Figure 2).

- Category A (Strategic Zone): Positioned near the entrance and on front-facing racks (yellow). This minimizes the travel distance for high-value components, directly addressing the "prolonged search times" identified in the initial problem statement.
- Category B (Standard Zone): Located on the middle racks (marked in blue). This placement balances accessibility with storage density, ensuring that operators can retrieve medium-priority items without navigating to the far reaches of the warehouse.
- Category C (Bulk/Rear Zone): Allocated to rear racks. Given their low movement frequency and minimal financial impact, this placement optimizes the "prime real estate" of the warehouse for critical items.

Previous studies by Suta et al. (2025) and Rahayu and Santoso (2023) highlight the need for strict safety stock levels and frequent monitoring of Category A items to avoid operational disruptions. While Novriyandi and Nurkertamanda (2022) explored mathematical lot-sizing for ABC items, this study emphasizes the importance of physical placement alongside order quantity for operational efficiency. The strategic positioning of Category A items aligns with spatial efficiency theory, which shows that reducing retrieval time enhances productivity. By sitting these items near

primary access points, we addressed the logistical issues noted by Richards (2022) regarding item commingling. Unlike the probabilistic demand management approach emphasized by Mahadika et al. (2021), the findings at PT XYZ indicate that the primary bottleneck was not demand prediction but the chaotic retrieval process.

The findings confirm that systematic spare parts classification is essential for improving warehouse efficiency and reducing the machine downtime. This study supports previous research on integrated warehouse management, particularly the multi-criteria classification approach proposed by Torre et al. (2025), by demonstrating the effectiveness of the ABC analysis in categorizing spare parts into Classes A, B, and C to support operational decision-making. The results also align with the framework of Mohamud et al. (2023), which emphasizes the close relationship between warehouse layout and operational efficiency, and the findings of Buba et al. (2019) regarding the importance of accurate warehouse management for organizational performance. Furthermore, this study reinforces the view that effective spare parts management and layout optimization are critical for minimizing downtime and controlling operational costs (Banabakova et al. 2021; Banabakova et al. 2018).

Managerial implications

The findings of this study offer critical managerial implications for the manufacturing industry. First, capital optimization is achieved by reallocating budgets and intensifying supervision of Category A items, which represent the most valuable 8% of the inventory, to mitigate financial risks. Second, the proposed redesigned layout enhances operational productivity by minimizing 'search-and-find' time, leading to faster equipment repairs and reduced production downtime. Finally, the implementation of a systematic and visual storage guide promotes a standardized workflow, streamlining staff onboarding and reducing human errors in inventory documentation.



Figure 2. Proposed rack arrangement layout by category at PT XYZ

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

This study shows that ABC analysis is a vital tool for improving spare parts inventory control at PT XYZ by prioritizing items based on their economic value and usage intensity. Our findings support those of Putra et al. (2024) and Savira & Miharja (2024), who highlighted that the ABC classification effectively simplifies inventory monitoring. However, unlike previous studies that focused primarily on administrative control, this study makes a unique theoretical contribution by integrating ABC analysis with physical warehouse layout design. By bridging these two traditionally siloed streams of research inventory control and spatial optimization this study advances the literature on integrated WM. It provides a conceptual framework demonstrating that warehouse efficiency is not merely an operational outcome but the result of synchronized inventory-spatial strategies.

In practice, moving from a reactive storage system to a systematic, value-based model has greatly improved the organization of warehouses. This confirms that aligning inventory priorities with physical placement is essential for an efficient warehouse system, helping to solve the logistical challenges common in manufacturing environments. Although the proposed framework provides a robust template for the refined sugar industry, we acknowledge that its performance is context dependent. Therefore, future research should test this integrated model across more diverse industrial scales to refine its theoretical boundary conditions. Ultimately, this study demonstrates that systematic physical grouping is a universal requirement for high-performance manufacturing environments, offering a scalable strategy that transcends specific industry boundaries to enhance inventory management practices.

Recommendations

It is recommended that PT XYZ develop a new, structured warehouse layout based on the results of the ABC analysis to facilitate effective item management and monitoring. Additionally, the company should provide training for employees on the importance of inventory management and the use of the ABC Analysis, enabling them to understand the system's functioning and benefits. Regular evaluations of the inventory management system are also advised to ensure that the applied methods remain relevant and effective while adapting to changes in the company's operational needs.

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