Optimizing Fabric Storage using Dedicated Storage for Order Picking Efficiency: Arena Simulation at PT. ABC

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ABSTRACT

Order picking is a crucial process in warehouse management, where efficiency in retrieving items significantly impacts operational smoothness and the company's ability to meet product demand on time. PT ABC is a garment company that faces issues with order-picking activities in the fabric material warehouse. The material search process, which takes up to 70 minutes, is caused by an inefficient random storage system. This study aims to optimize material storage using the dedicated storage method and simulation with Arena software. With this approach, storage allocation based on buyers is implemented to improve the efficiency of material retrieval time. The simulation results indicate a reduction in material search time to 41.86 minutes, improving efficiency by 40.2%. The dedicated storage method has proven effective in enhancing warehouse operational efficiency, enabling the company to reduce material search time.

1. Introduction

PT ABC is a garment company that produces various finished garments such as sportswear, outdoor clothing, and other products for different brands. PT ABC operates several warehouses, including a material warehouse, finished goods warehouse, sample warehouse, and stock warehouse, which serve as storage for all products, including finished goods, samples, raw materials needed for production, and leftover items from production [1]. The material warehouse at PT ABC is divided into a fabric warehouse and an accessories warehouse. The main activities in the material warehouse include receiving, put-away, storage, order picking, and shipping [2]. Among these five activities, order picking is one of the most time-consuming activities in the warehouse, making efficiency in this process very important [3]. Order picking is the process of retrieving items from storage locations based on production demands [4].

Based on observations conducted in PT ABC's material warehouse, fabric order-picking activities have become crucial as they affect the production process. This problem is caused by the ineffectiveness of the material storage system, where operators struggle to find the storage locations, resulting in a lengthy time for material retrieval. The order-picking process consists of five primary activities carried out sequentially: submission of the pick list to the admin, submission to the operator, searching for storage locations, grouping the material by QC, and delivering the material to the cutting department. To provide a clearer picture of the time duration of each activity, the graph in Figure 1 is arranged in order of time from highest to lowest.

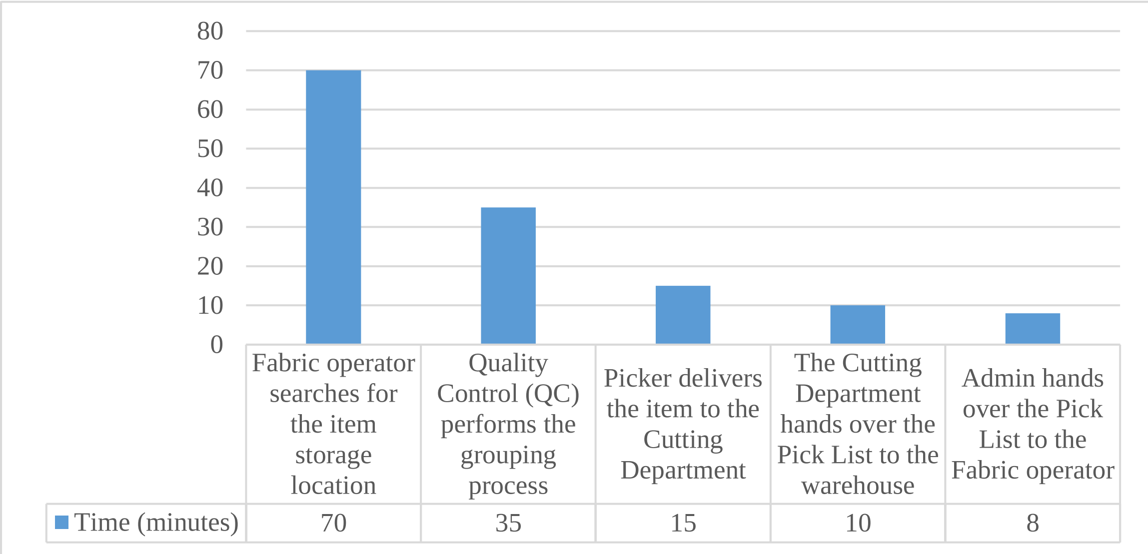

Figure 1. Order Picking Time

Figure 1 shows the time required to complete each stage in the order-picking process at PT ABC's material warehouse. Overall, searching for the storage location is the most time-consuming activity, taking about 70 minutes, compared to other much faster activities. This activity accounts for the majority of the total order-picking process time, so the most significant improvements can be made in this activity to enhance the overall efficiency of the order-picking process. The lengthy time spent searching for items is due to the difficulty locating the storage areas. This issue arises from disorganized and untidy storage, where fast-moving materials are mixed with dead stock, making identification difficult. This is compounded by PT ABC's random storage policy, where materials are placed on available empty pallets without considering their type or usage frequency.

The order-picking process in PT ABC’s material warehouse is conducted manually using a reach truck, and there is no system to track material storage locations. As a result, the random storage method is considered inefficient and suboptimal for supporting smooth warehouse operations for fabric materials [5]. Based on the issues in PT ABC's fabric material warehouse, an evaluation and improvement of the fabric storage allocation are needed. The goal of this improvement is to simplify warehouse operations, particularly in the material storage and retrieval processes, and reduce the time spent searching for materials to enhance the overall operational efficiency of the warehouse.

The research conducted by Moengin, Nadya, and Adisuwiryo [6] focuses on the raw material warehouse in the automotive manufacturing company PT Braja Mukti Cakra, using the shared storage method. This study addresses the long material search times due to the need for more labeling and classification of material types on racks or pallets. The results showed that this method reduced the raw material retrieval time by 41.76%, from 122.23 hours to 71.18 hours.

Rosihin, Ma'arij, Cahyadi, and Supriyadi [7] used the class-based storage method to research a manufacturing company's coil warehouse. This study aimed to reduce travel time and simplify the search for items previously disrupted by the random storage method. The results showed that the delivery time of goods from the fast-moving area to the shipment area was reduced to just 1 minute, while distance efficiency improved by 66% when fast-moving materials were placed closer to the shipping area.

Amalia, Fayaqun, and Bisma [8] researched a food product warehouse in a manufacturing company by applying the dedicated storage method. This study aimed to address the long order picking time caused by random storage, which resulted in difficulties in stock monitoring. The results showed a reduced order picking time from 56.02 minutes to 26.71 minutes.

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Previous research on the layout of goods storage in manufacturing warehouses, particularly addressing issues in the order-picking process, has been the foundation for the author to develop new research focused on allocating fabric material storage in the garment industry. This study proposes improvements to the allocation of fabric material storage in PT ABC's material warehouse using the dedicated storage method, which involves fixed-location storage based on the buyer [9]. Storage based on the buyer was chosen because it allows for grouping materials according to each buyer's specific needs, making the search and retrieval process simpler and reducing the potential for errors in picking the goods.

Referring to the research conducted by Heitasari, Sono, and Yempori [10], Arena software was used to optimize cross-docking operations at PT X's warehouse. The Arena simulation identified the best scenario to reduce waiting time, with an output of Waiting Time of 0.4656 hours. This study proves that Arena software can simulate warehouse processes with time output. Furthermore, Arena offers high flexibility in modeling complex processes with easy-to-understand visualizations and can accurately represent multiple systems virtually [11]. Therefore, the simulation using Arena software is designed to compare the actual time with the proposed time after the improvement of fabric material storage allocation to evaluate the efficiency of order-picking activities, particularly when searching for items.

2. Methods

Research methodology is a stage in research that is structured systematically and scientifically and used to solve research problems [12]. The research was conducted through direct observation at PT ABC. This research process includes data collection, data processing, proposed layout design, simulation, and results analysis, as shown in Figure 2.

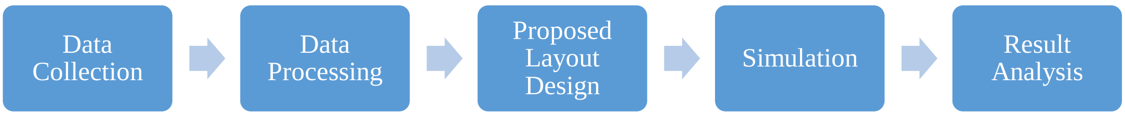

Figure 2. Research Stages

2.1 Data Collection

The sources of data required for this research are as follows:

a. Primary Data

Primary data refers to data obtained through direct observation or data acquired through measurement using instruments in the fabric material warehouse [13]. The primary data used in this study includes the layout of PT ABC's material warehouse, the number of racks, pallet sizes, and the number of items per pallet.

b. Secondary Data

Secondary data is sourced from company documents that can be obtained from the administration through the software used to record every inbound and outbound transaction of goods [14]. The secondary data used in this research includes data on material types and data on items entering and leaving for four months.

2.2 Data Processing

The data processing conducted in this study uses the dedicated storage method with the following steps:

a. Calculating Space Requirement (Sj)

Space requirement refers to the calculation to determine the storage location for specific materials [15]. Formula (1) aims to ensure that only one product is placed at the storage location of the warehouse rack [16]. The following is the formula used to calculate the space requirement:

$$S_j = \frac{Average\ Receipt}{Storage\ Capacity\ of\ Material/slot} \quad (1)$$

b. Throughput Calculation (Tj)

The throughput calculation aims to determine the average value of material receiving and shipping activities per period [17]. The following is the formula used to calculate throughput:

$$T_j = \left(\frac{Average\ Receipt}{Carrying\ Capacity}\right) + \left(\frac{Average\ Issues}{Carrying\ Capacity}\right) \quad (2)$$

c. Assignment

i. Material Ranking

Material ranking is based on the comparison of throughput (Tj) with space requirement (Sj). The purpose of ranking products is to identify materials with the highest level of importance down to those with the lowest level of importance [18]. Materials with a high level of importance can be determined by a high T/S ratio. The placement of materials is done based on the buyer. The formula used to calculate this ranking is as follows:

$$\frac{T_j}{S_j} = \frac{Throughput}{Space\ Requirement} \quad (3)$$

ii. Calculation of Material Transfer Distance

Rectilinear distance is a method for calculating the distance between two midpoints, measured along a path using perpendicular lines to each other [19]. The distance calculation using rectilinear distance is performed to determine the placement of materials, where those with the highest ranking will be placed in storage closest to the I/O point, while those with the lowest values will be placed in storage farthest from the I/O point [20]. The following is the formula for calculating rectilinear distance:

$$d_{ij} = |xi - xj| + |yi - yj| \quad (4)$$

Where:

d_{ij} = distance from area i to area j

x_i = x-axis coordinate of area i

x_j = x-axis coordinate of area j

y_i = y-axis coordinate of area i

y_j = area y-axis coordinate

2.3 Proposed Layout Design

Reorganizing the storage of fabric materials to create a more efficient storage allocation by grouping materials based on the dedicated storage method.

2.4 Simulation

Simulation using Arena software is carried out to compare the current operational conditions with the proposed conditions. This simulation aims to measure the effectiveness of the proposed order-picking time changes in layout and storage allocation.

2.5 Results Analysis

At this stage, the results of data processing will be analyzed to evaluate the effectiveness of the proposed method. The simulated data is compared with the actual conditions to see the changes in order picking time. This analysis aims to assess the extent to which improvements in storage allocation can improve warehouse operational efficiency.

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3. Results and Discussions

This results and discussion section outlines the findings from each stage of the research methodology, including the initial data collection stage, data processing, proposed layout design, simulation, and the final stage of order picking efficiency analysis.

3.1 Data Collection Results

The data used in this study includes the data on incoming and outgoing goods over the past 4 months, as shown in Table 1.

Table 1. Data of Goods In and Out of the Fabric Warehouse

Buyer	Total Receipt Quantities (Yard)				Total Issues Quantities (Yard)			
	January	February	March	April	January	February	March	April
ART	95,552	142,648	151,717	100,132	64,013	172,984	151,710	63,862
ARM	81	193	9,126	6,879	100	319	9,265	6,855
ATM	872	211	8,079	17,564	375	165	7,878	12,903
BTN	48,479	39,686	8,876	93,368	41,095	39,111	9,116	3,092
DER	2,192	516	434	46,512	1,245	516	431	26,747
HBS	11,525	74,318	76,461	13,792	10,031	74,374	80,664	10,125
INV	4,934	1,641	11,996	2,329	2,336	1,644	12,934	1,638
KMD	146,267	3,554	604	39,958	143,310	3,702	382	170
LBN	47,979	74,769	32,601	36,158	44,796	75,096	31,740	28,701
SLM	5,740	8,200	45,312	17,055	2,812	8,175	42,871	4,348

Table 1 illustrates the material flow in PT ABC's fabric material warehouse, including the amount of material received from suppliers (inbound) and the amount of material released to meet production needs (outbound). The fluctuation in the receipt and expenditure of material varies each month, with the amount of material received generally being higher than the amount of material released overall. The information in Table 1 is used as a basis for calculating the storage requirements for each material and understanding the average activity of material receipt and expenditure per time period (month). Additionally, the layout of PT ABC's fabric material warehouse is used in this study to analyze the mapping of material storage locations, as shown in Figure 3.

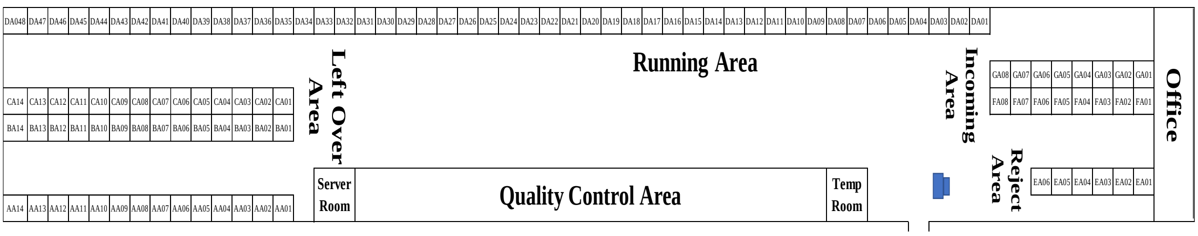

Figure 3. Top View Layout of the Fabric Warehouse at PT ABC

The fabric material warehouse at PT ABC measures 11m² x 78m², with 112 racks, each having four levels, totaling 448 slots. The rack capacity per level is 27 fabric rolls, calculated by dividing the pallet size by the fabric roll size, with each roll being 100 yards. The warehouse is divided into four areas: incoming area, reject area, running area, and leftover area. The incoming area is used to temporarily store newly arrived fabric that will be inspected for quality and quantity before passing through QC. The reject area stores fabric that fails QC. The running area holds fabric ready for production, while the leftover area stores excess fabric from production.

3.2 Data Processing Results

The data processing in this study used the dedicated storage method, a system where each item has a fixed and specific storage location. This method facilitates arranging and retrieving items when needed, as each item has a designated location [21]. This method is highly suitable for this study since materials are stored based on the buyer. Below are the steps for calculating the dedicated storage method at PT ABC:

a. Space Requirement

The space requirement calculation determines how much storage space or slots are needed for each product. This calculation is important to ensure the warehouse has sufficient storage capacity. The calculation of space requirements based on Formula (1) is presented in Table 2.

Table 2. Results of Space Requirement Calculation

Buyer	Total Receipt Quantities				Average Receipt (YD)	Average Receipt (Roll)	SKU/slot Capacity	Space Requirement
	January	February	March	April				
ART	95,552	142,648	151,717	100,132	122,512	1,226	27	45
ARM	81	193	9,126	6,879	4,070	41	27	2
ATM	872	211	8,079	17,564	6,681	67	27	2
BTN	48,479	39,686	8,876	93,368	47,602	477	27	18
DER	2,192	516	434	46,512	12,413	125	27	5
HBS	11,525	74,318	76,461	13,792	44,024	441	27	16
INV	4,934	1,641	11,996	2,329	5,225	53	27	2
KMD	146,267	3,554	604	39,958	47,596	476	27	18
LBN	47,979	74,769	32,601	36,158	47,876	479	27	18
SLM	5,740	8,200	45,312	17,055	19,077	191	27	7
Total Storage Locations								**132**

Table 2 shows the results of the storage space requirement calculation with a maximum capacity per slot of 27 rolls of fabric. This calculation indicates that the storage requirements for each buyer vary, depending on the average material receipt for each buyer. Buyer ART requires the most slots, with 45 slots needed to store 1,226 rolls of fabric received. Meanwhile, buyers ARM and INV require the fewest slots, only two slots, as the amount of material received is smaller compared to other buyers. The slot requirement calculation is rounded up to ensure that all material can be stored optimally. Overall, the total number of slots required for placing material from all buyers in the warehouse is 132.

b. Throughput

Throughput is the calculation used to measure the activity of receiving/retrieving items from storage racks. The receiving/retrieving activity in the material warehouse of PT ABC uses a material handling reach truck with a carrying capacity of 1 pallet, which can hold 27 fabric rolls for each buyer. The throughput calculation based on Formula (2) is presented in Table 3.

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Table 3. Throughput Calculation Results

Buyer	Average Receipt (Roll)	Average Issues (Roll)	Carrying Capacity	Throughput
ART	1226	1131	27	87
ARM	41	41	27	4
ATM	67	53	27	4
BTN	477	231	27	27
DER	125	72	27	8
HBS	441	438	27	33
INV	53	46	27	4
KMD	476	369	27	32
LBN	479	451	27	35
SLM	191	146	27	13

c. **Assignment**

i. Material Ranking

Ranking materials based on buyers refers to comparing throughput value with space requirement, aiming to determine which materials come from buyers with a high level of importance and serve as a reference for material placement. The ranking of materials based on the buyer according to Formula (3) is presented in Table 4.

Table 4. Results of Buyer Ranking

Buyer	Space Requirement	Throughput	Assignment
ARM	2	4	3
HBS	16	33	3
INV	2	4	3
ART	45	87	2
ATM	2	4	2
BTN	18	27	2
DER	5	8	2
KMD	18	32	2
LBN	18	35	2
SLM	7	13	2

ii. Calculation of Material Transfer Distance

Distance calculation using Rectilinear Distance is performed to determine material placement, where materials with the highest rankings are stored closest to the I/O point, while those with the lowest rankings are stored furthest away. The travel distance here refers to the distance that the material handling reach truck must cover to reach the designated slot, starting from the I/O point [22]. The distance for moving goods from rack DA, which will be used for storing running materials, is calculated assuming each rack level has the same distance. This calculation uses a pattern of horizontal and vertical movement in the warehouse, reflecting the actual activities of the operator. The values x_i and y_i represent the coordinates of the storage location, while x_j and y_j are the coordinates of the exit point.

The difference in coordinates represents the horizontal and vertical distance from each storage location to the exit. The distance calculation results using Formula (4) are presented in Table 5.

Table 5. Results of Rectilinear Distance Calculation

Movement Distance	xi	yi	xj	yj	$\lvert xi - xj \rvert$	$\lvert yi - yj \rvert$	D_{ij}
DA02	47	1	45	9	2	8	10
DA03	46	1	45	9	1	8	9
DA04	45	1	45	9	0	8	8
DA05	44	1	45	9	1	8	9
DA06	43	1	45	9	2	8	10
DA07	42	1	45	9	3	8	11
DA08	41	1	45	9	4	8	12
DA09	40	1	45	9	5	8	13
DA10	39	1	45	9	6	8	14
DA11	38	1	45	9	7	8	15
DA12	37	1	45	9	8	8	16
DA13	36	1	45	9	9	8	17
DA14	35	1	45	9	10	8	18
DA15	34	1	45	9	11	8	19
DA16	33	1	45	9	12	8	20
DA17	32	1	45	9	13	8	21
DA18	31	1	45	9	14	8	22
DA19	30	1	45	9	15	8	23
DA20	29	1	45	9	16	8	24
DA21	28	1	45	9	17	8	25
DA22	27	1	45	9	18	8	26
DA23	26	1	45	9	19	8	27
DA24	25	1	45	9	20	8	28
DA25	24	1	45	9	21	8	29
DA26	23	1	45	9	22	8	30
DA27	22	1	45	9	23	8	31
DA28	21	1	45	9	24	8	32
DA29	20	1	45	9	25	8	33
DA30	19	1	45	9	26	8	34
DA31	18	1	45	9	27	8	35
DA32	17	1	45	9	28	8	36
DA33	16	1	45	9	29	8	37
DA34	15	1	45	9	30	8	38
DA35	14	1	45	9	31	8	39
DA36	13	1	45	9	32	8	40
DA37	12	1	45	9	33	8	41
DA38	11	1	45	9	34	8	42

Table 5 presents the results of the material movement distance calculation from the storage location to the exit for each location on rack DA. This calculation shows the variation in the movement distance between storage locations. The larger the value of D_{ij}, the greater the distance the material needs to be moved, which can affect the order picking time. This information helps determine the storage location

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of each buyer's material, so that fast-moving items can be placed closer to the exit, at storage locations with the smallest movement distance.

3.3 Proposed Warehouse Layout

The storage allocation for materials based on buyers with the highest T/S values is placed in slots with the shortest travel distances. Buyers are placed in rack DA, the running area, to facilitate access and expedite the item retrieval process. Figure 4 is an image of the proposed layout showing the allocation of material storage based on buyers.

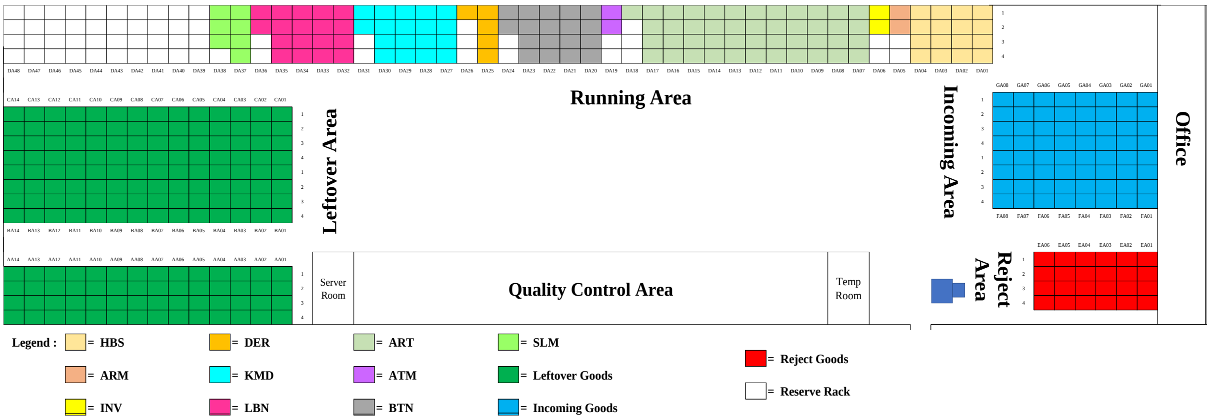

Figure 4. Proposed Fabric Warehouse Layout

After implementing the dedicated storage method, out of the total 448 available slots, 132 slots are used for storing running materials, while the remaining slots on rack DA are used as reserves.

3.4 Proposed Warehouse Simulation

After allocating storage for materials based on buyers, the next step is to create a simulation model using Arena software. This model is designed to visualize and analyze the efficiency of item retrieval in the warehouse. Several events occur in this process (Figure 5), including:

a. The arrival process of the cutting operator is represented by the 'Create' module.
b. The process of handing the pick list to the warehouse admin is represented by the 'Process' module.
c. The process of handing the pick list to the picking operator is represented by the 'Process' module.
d. The process of managing the search time for items in storage locations is represented by the 'Assign' module.

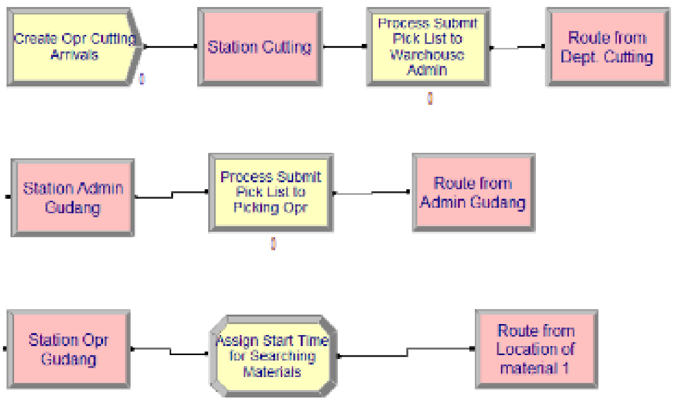

Figure 5. Arena Simulation Model

After simulating the order-picking model, a report from the system was generated, displaying data related to the duration of the fabric material search process in the warehouse. According to the report, the average time required to search for items in one pick list is 0.6977 hours or approximately 41.86 minutes, as shown in Figure 6.

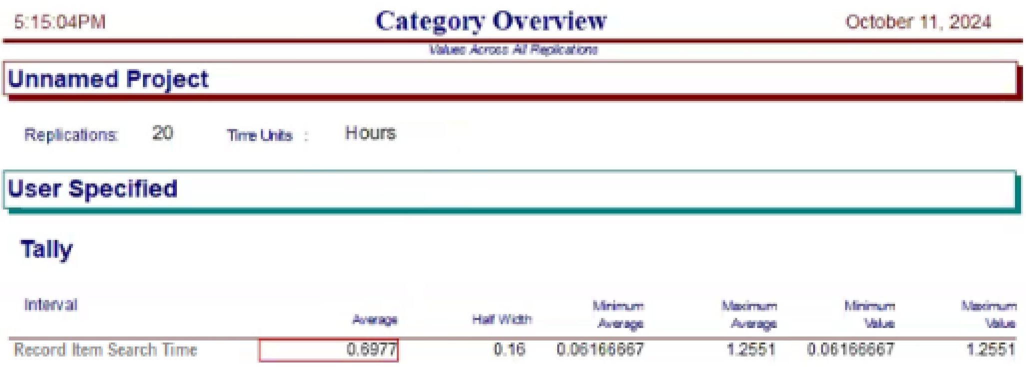

Figure 6. Item Search Time Report

This result indicates a significant reduction in item search duration, where the search time previously reaching 70 minutes has been reduced to 41.86 minutes, representing an efficiency improvement of 40.2%, as shown in Table 6.

Table 6. Comparison of Actual Time with Proposed Time

Order Picking Activity	**Actual Time (minute)**	**Proposed Time (minute)**
The Cutting Department hands over the Pick List to the warehouse	10	10
Admin hands over the Pick List to the Fabric operator	8	8
Fabric operator searches for the item storage location	**70**	**41.86**
QC performs the grouping process	35	35
The picker delivers the item to the Cutting Department	15	15

Table 6 compares each activity's actual time and proposed time in the order-picking process. The most significant time difference occurs during the material search stage by the operator. Meanwhile, the time for other activities remains stable, indicating that the improvements focus solely on optimizing storage locations without affecting other activities. The reduction in material search time from 70 minutes to 41.86 minutes demonstrates the achievement of the research goal: to improve the efficiency of the order-picking process by reducing the time spent searching for materials.

4. Conclusion

This study successfully identified the main issues in the order-picking process at the material warehouse of PT ABC, specifically the disorganized storage system. By implementing the dedicated storage method, the search time for materials can be significantly reduced. The Arena software simulation demonstrated that a systematic allocation of material storage improved efficiency by 40.2%, decreasing from 70 to 41.86 minutes. These results indicate that using dedicated storage can enhance the operational efficiency of the warehouse.

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