Analysis of Material Storage in The Raw Material Warehouse Using the Shared Storage Method at PT.XYZ

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Abstract. PT.XYZ is currently experiencing problems in improving the efficiency of raw material storage in the warehouse, as seen from the inefficient placement of materials and the length of time to retrieve materials. The purpose of this research is to provide a proposal for improving the layout of the raw material warehouse by using the shared storage method and applying the FIFO (First In First Out) method to keep the order of the outgoing materials in accordance with the order of entry, so as to improve the efficiency of the warehouse layout. By applying the shared storage method, the data analysis proposes adding two storage racks based on material type to increase the total rack capacity from 9000 to 10800 boxes. The arrangement of storage racks is based on the frequency of material requests, so that frequently requested materials are placed closer to the entrance. It is hoped that this proposal can improve the overall operational efficiency of the warehouse by avoiding material storage in inappropriate locations and speeding up material retrieval to improve warehouse efficiency.

Keywords: Layout, Shared Storage Method, Warehouse

1 Introduction

Along with the rapid advancement of the shipping industry and technology, more complex problems arise in this industry. In the shipping industry, a frequent problem is warehouse layout. The warehouse serves as a storage place for raw materials to be processed and finished products that are ready to be shipped. However, the shipping industry often experiences problems with the arrangement of raw material warehouses, and these problems still occur even though they are only related to warehouse layout. An optimized raw material warehouse layout will help companies reduce losses, reduce operational costs, and facilitate the process of getting goods in and out.

According to Mulyati et al. (2020), the warehouse serves as a place to produce and store various types of products, including raw, semi-finished, and finished materials. Warehouses are essential to a company's operational planning because they not only serve as a place of storage, but also improve the company's

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services and efficiency. An effective warehouse layout can improve warehouse performance.

PT.XYZ is a company engaged in ship building, ship repair and conversion. PT.XYZ has a 1,100 m2 raw material storage warehouse that stores various kinds of raw materials such as Bolt & Nut, Flange, Elbow, Bulb Lamp, Stud Bolt, U-Bolt. The problem faced by the warehouse at PT.XYZ is the irregularity in the preparation of materials which can hamper the delivery process time and make the warehouse storage capacity not fully utilized, so this causes the handpallet material handling process to be ineffective and makes it difficult for handpallet operators to retrieve materials in the warehouse. Another condition faced is the improper placement of materials in one area, where one area should store one type of material but currently there are still materials mixed with other materials. In addition, materials with a high frequency of delivery and frequent in and out have a material handling distance that is too far from the exit (loading dock). This causes the material handling distance to be longer and less effective.

From the problems and descriptions above, researchers will analyze the existing condition of the raw material warehouse at PT.XYZ. With a better understanding of the existing conditions, it is necessary to redesign the layout of the raw material warehouse to make it more organized and efficient. This will shorten the distance of material handling movements and make it easier for operators in the process of picking materials and data collection every month.

One of the solutions applied is to use the shared storage method. With this method, it is expected that the warehouse layout can be reorganized more efficiently, so that the distance of material handling movements will be shorter and the process of picking materials and data collection will be more efficient. The shared storage method involves organizing storage areas based on the floor area of the warehouse, by sorting the areas from closest to furthest from the entrance-exit. This allows the placement of materials that will be shipped immediately in the area closest to the exit.

Based on the previous explanation, the purpose of this study is to provide a proposal for improving the layout of the raw material warehouse so that the company can optimize the function of the raw material warehouse in PT.XYZ.

2 Literature Review

2.1 Definition of layout

Murdifin and Mahfud (2011) explain that layout is an operational strategy that has a significant impact on the company's operational efficiency in the long term. An optimal layout will contribute to increasing the company's productivity.

Overall, layout refers to the design of elements, work centers, and equipment that affect operational efficiency in the long term. The strategic implications of layout include business processes related to capacity, process, flexibility, and cost (Heizer and Render, 2009).

2.2 Purpose of Layout Planning

According to Sri Tomo Wignjosoebroto (2003), the main objective in layout design is to reduce total costs associated with cost elements, such as:

1) Construction and installation costs to build machines and other product facilities;
2) Material handling costs;
3) Production maintenance costs, security, and semi-finished product storage costs.

2.3 Definition and Function of Warehouse

According to Warman (2012), a warehouse is a building used to store goods, whether raw materials, semi-finished goods, spare parts, or goods that will be used in the production process.

According to Wijayanti (Pradnya, 2020), warehouse functions based on their activities are as follows:

1) Receiving, is an activity that includes receiving goods to the point of delivery, determining the quantity of goods, and delivering goods to storage or other locations needed.
2) Inspection and quality control, which is the receiving process to ensure the quality of the goods sent by the supplier in accordance with the order.
3) Repackaging, which is the process of unpacking products received in bulk from suppliers and repackaging them into smaller quantities or combining multiple product forms.
4) Putaway, the activities of the goods have arrived at the warehouse and the documents have been checked, the next step is to place the goods in the warehouse according to the existing stock.
5) Storage, is a place to store goods including raw materials, semi-finished goods, and finished goods.
6) Order Picking, which is the process of picking goods from the warehouse according to demand.
7) Sortation, the process of distributing goods according to individual needs or the required location, and calculating the amount of goods needed.
8) Packaging and Shipping, activities that include inspecting goods, packing goods into containers, documenting shipments, sorting goods to determine shipping costs, and receiving goods until loading into trucks.
9) Cross Docking, the activity of receiving goods at the warehouse which is immediately followed by the shipping process.
10) Replenishing, the activity of replenishing stock at the main picking point in the warehouse.

2.4 Material Handling

Material handling, can be done manually or using automated methods, can be done once or repeatedly, can be allocated to a fixed location or randomly, and can be placed on the floor or above it. In the context of two workstations or departments with coordinates (x,y) and (a,b), the calculation of the distance between two midpoints can be done using several methods, as described by Purnomo (2004), as follows:

1) *Rectilinear Distance*
   Distances are measured along a path using lines that are perpendicular (orthogonal) to each other. An example is the movement of materials that occurs along straight aisles in a factory.
   $$dij = |x-a| + |y-b$$

2) *Euclidean Distance*
   Distance is measured between two points along a straight line path. The Euclidean distance can be depicted as a straight conveyor connecting two work stations.
   $$dij = \sqrt{[(x - b)^2 + (y - b)^2]}$$

3) *Squared Euclidean Distance*
   The distance is divided into two parts by a controlled trajectory line. For example, in a guided vehicle system, the vehicle must follow a predetermined path in a controlled trajectory network. Therefore, the flow path can have a longer distance compared to Reclinear and Euclidean trajectories.
   $$dij = (x - a)^2 + (y - b)^2$$

2.5 Shared Storage Method

According to Ekoanindiyo (2012), the shared storage method is a storage approach that combines several types of materials in one special area. The shared storage method is a warehouse layout arrangement by applying the FIFO (First In First Out) principle, where goods that will be delivered faster are placed in the storage area closest to the entrance or exit. The advantage of this method is its ability to store several types of products in sequence.

The relevant variables in the shared storage method include:

1) Length of work process
2) Delivery time of each product
3) Number of products in each order
4) Frequency of orders in each time period
5) Distance between each storage area and the exit and entrance doors
6) Amount of space required

3 Research Methods

The research was conducted at PT.XYZ, especially in the incoming goods, stored goods, and outgoing goods in the warehouse. Data is collected through direct field research, secondary data, interviews, and literature studies. The analysis method used is the shared storage method, with the following steps:

a. Create an initial storage layout
b. Determine the layout with the shared storage method
c. Creating a new layout
d. Comparing the old layout and the new layout

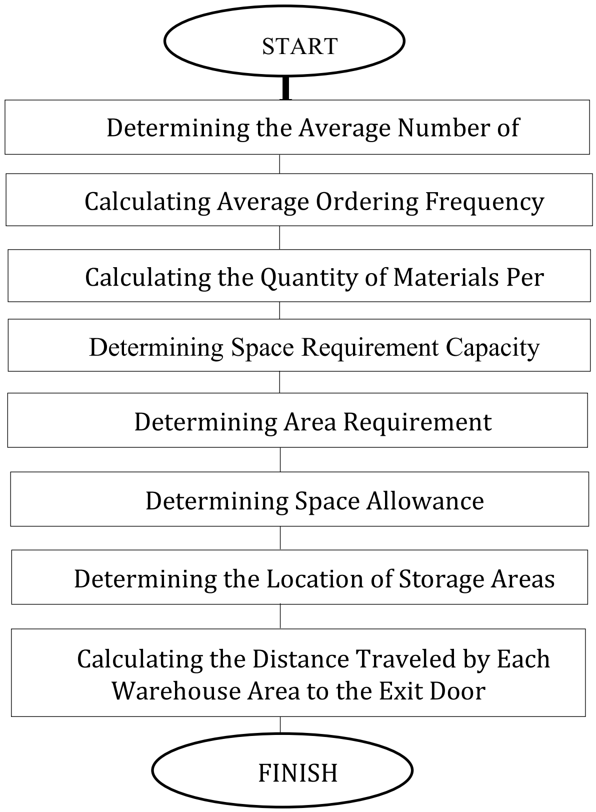

Figure 1: Stages of Data Processing

4 Results and Discussion

4.1 Material Receiving and Dispensing

Material receiving and dispensing data is used to determine the frequency of movement of each type of material and the maximum capacity of storage space required. This data covers a 6-month period. The data used is data on the receipt and retrieval of materials in the PT.XYZ warehouse from January to June 2023.

Based on the data in Table 1, the most receipt of bolt & nut material in April amounted to 34453 boxes. Conversely, the least material receipt occurred in March for stud bolt material amounting to 134 boxes.

Table.1 Receipt and Expenditure Data of PT XYZ for 6 months

Month / Type Material	Desc.	Jan	Feb	Mar	Apr	Mei	Juni	Total	Average
Flange	In	1950	2561	2645	1607	2567	3538	14868	2478
	Out	1825	2465	2580	1567	2525	3500	14462	2410
Elbow	In	981	1521	1373	1721	1685	1277	8558	1426
	Out	826	1325	1273	1573	1635	1200	7832	1305
Stud-Bolt	In	422	520	134	533	310	261	2180	363
	Out	406	515	128	523	298	261	2131	355
U-Bolt	In	483	210	340	537	210	284	2064	344
	Out	463	200	325	530	180	234	1932	322
Bulb Lamp	In	200	800	430	340	830	710	3310	552
	Out	191	793	415	327	819	700	3245	541
Bolt & Nut	In	5868	5492	11237	34453	15297	32012	104359	17393
	Out	5787	5402	11117	34253	14897	31202	102658	17110

Sumber: PT.XYZ

4.2 Determine The Number of Requests Per Month

The data used to calculate the average demand each month is the total goods that come out of each material for 6 months. By calculating the data, the average monthly demand for each material can be found as shown in Table 2.

Table.2 Average Demand per month

Type of Material	Average Demand/Month (box)
Bolt&Nut	17110
Flange	2410
Elbow	1305

Type of Material	Average Demand/Month (box)
Bulb Lamp	541
Stud-Bolt	355
U-Bolt	322
Total	**22043**

4.3 Average Order Frequency of PT. XYZ

By looking at the number of orders received each month, we can calculate the average order frequency for each type of material per month. The average order frequency data for each type of material per month is shown in Table 3:

Table.3 Average Order Frequency of PT. XYZ

No	Type of Material	Order Frequency per month						Average
		1	2	3	4	5	6	
1	Bolt&Nut	6	4	5	4	5	4	5
2	Flange	4	3	5	4	5	4	4
3	Elbow	3	2	4	3	4	3	3
4	Bulb Lamp	2	1	2	1	2	2	2
5	Stud-Bolt	3	2	4	2	4	3	3
6	U-Bolt	2	1	2	2	3	2	2

4.4 Number of Materials Per Order for Each Type of Material Per Month

The total amount of material per order for each type of material can be calculated by dividing the monthly demand by the monthly delivery frequency. This can be seen in Table 4:

Table.4 Number of materials per order for each type of material per month

No	Type of Material	Total Demand per month	Frequency of Demand per month	Number of Request per order
1	Bolt&Nut	17.110	5	3.422
2	Flange	2.410	4	603
3	Elbow	1.305	3	435
4	Bulb Lamp	541	2	271
5	Stud-Bolt	355	3	118
6	U-Bolt	322	2	161
	Total	22.043		

4.5 Space Requirement

In evaluating space requirements, it is necessary to analyze the amount of raw materials in the warehouse according to the daily requirements for the production line and the lead time of each raw material. This is important because each shelf has a different amount and type of raw material. From the data in Table 5, we can calculate the daily requirements for the production line by multiplying the number of requirements per shipment by the number of types of raw materials available on the shelf. The amount of raw materials in the warehouse is obtained by multiplying the average lead time by the daily requirement for the production line.

Table.5 Quantity needed per shipment

No	Type of Material	Quantity Required per shipment (box)	Quantity of Raw Materials on the shelf	Average Lead Time (Days)	Daily requirement to production line (box)	Number of Raw Materials in the Warehouse (box)
1	Bolt & Nut	12	6	2	72	144
2	Flange	10	5	2	50	100
3	Elbow	8	4	2	32	64
4	Bulb Lamp	7	4	2	28	56
5	Stud-Bolt	6	3	2	18	36
6	U-Bolt	5	2	2	10	20

4.6 Determination of Required Storage Area

In calculating the shelf storage area and its needs, it is necessary to calculate the amount of raw materials in one level of shelf stacks, and the total raw materials arranged in one area with shelves. PT XYZ's raw material warehouse has a standard five-level stack on the shelf. Below is the calculation of shelf planning. The amount of material in one shelf is calculated by multiplying the number of shelf levels by the amount of raw materials in one level. To calculate the number of shelves needed, divide the total raw materials in the warehouse divided by the amount of material in one shelf. This calculation can be seen in table 6.

Table.6 Rack Planning Calculations

No	Type of Material	Shelf Level	Quantity of Raw Materials in one level	Many Raw Materials in one area (box)	Number of Raw Materials in the Warehouse (box)	Number of Shelf areas
1	Bolt & Nut	5	24	120	144	1
2	Flange	5	20	100	100	1
3	Elbow	5	16	80	64	1

No	Type of Material	Shelf Level	Quantity of Raw Materials in one level	Many Raw Materials in one area (box)	Number of Raw Materials in the Warehouse (box)	Number of Shelf areas
4	Bulb Lamp	5	14	70	56	1
5	Stud-Bolt	5	12	60	36	2
6	U-Bolt	5	10	50	20	2

4.7 Warehouse Initial Shelf Storage Capacity Data

Table 7 shows the storage system carried out at PT.XYZ, which consists of 20 shelves. Each shelf has a variant number of boxes and materials inside.

Table.7 Initial shelf storage data of PT.XYZ

No	No.Rak	Type of Material	Number of box/rack	Quantity of material/ box
1	R01-R04	Flange	3000	30000
2	R05-R08	Elbow	1000	10000
3	R09-R10	Stud-Bolt	300	3000
4	R11-R12	U-Bolt	200	2000
5	R13-R15	Bulb Lamp	500	5000
6	R16-R20	Bolt&Nut	4000	40000
	Total		**9000**	**90000**

4.8 Storage Area Layouts

After understanding the space requirements, we can determine the amount of area needed. With a warehouse size of 50 m x 22 m = 1,100 m², the arrangement of storage locations can be adjusted to the existing space requirements (warehouse width and storage area). The following is the old storage area layout design and the proposed new storage area layout. Figure 2 shows the initial warehouse layout while Figure 3 shows the proposed warehouse layout.

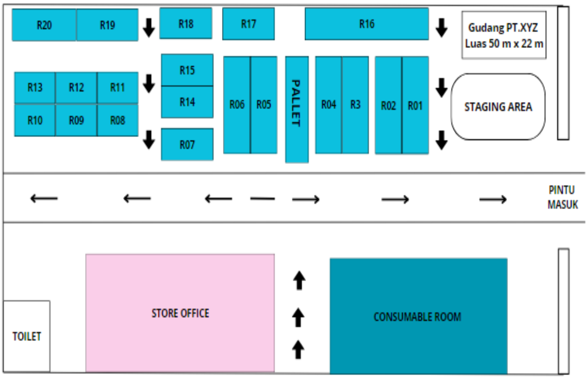

Fig.2 Initial warehouse layout

Image Description:

R01 : Flange	R06 : Elbow	R11 : U-Bolt	R16 : Bolt & Nut
R02 : Flange	R07 : Elbow	R12 : U-Bolt	R17 : Bolt & Nut
R03 : Flange	R08 : Elbow	R13 : Bulb Lamp	R18 : Bolt & Nut
R04 : Flange	R09 : Stud-Bolt	R14 : Bulb Lamp	R19 : Bolt & Nut
R05 : Elbow	R10 : Stud-Bolt	R15 : Bulb Lamp	R20 : Bolt & Nut

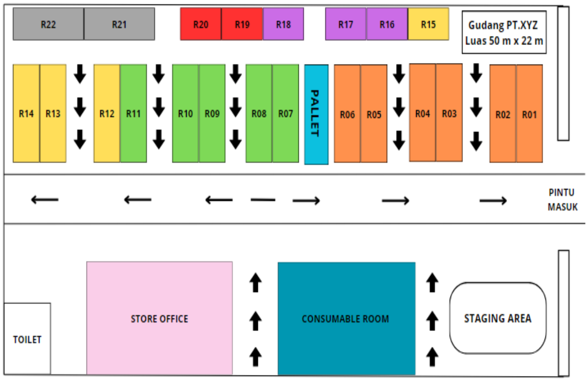

Fig.3 Layout of proposed warehouse

BLOCK DIVISIONS:

Bolt&Nut	Alloccation : R01-R06	(Orange Area)
Flange	Allocation : R07-R11	(Green Area)
Elbow	Allocation: R12-R15	(Yellow Area)
Bulb Lamp	Allocation : R16-R18	(Purple Area)
Stud-Bolt	Allocation : R19-R20	(Red Area)
U-Bolt	Allocation : R21-R22	(Gray Area)

The proposed layout design, after adding shelves and arranging shelf numbers for each material, is as shown in Figure 3. By adding 2 additional shelves, the warehouse can be optimized for better efficiency and ease the process of finding materials. In addition, this action also aims to store materials with the highest demand, such as Bolt&Nut, which is placed close to the warehouse door.

4.9 New Shelf Storage Capacity Data

After doing the calculations, it was proposed to add 2 shelves which initially consisted of only 20 shelves. With the additional 2 shelves, the number of boxes used increases from 9000 to 10800 boxes, as shown in Table 8. Each shelf is divided into 2-3 sections to increase efficiency and facilitate the process of finding materials.

Table.8 Storage Data of PT.XYZ New Rack

No	No.Rak	Type of Material	Number of box/rack	Quantity of material/ box
1	R01-R06	Bolt&Nut	2800	28000
2	R01-R06	Bolt&Nut	2000	20000
3	R07-R11	Flange	2200	22000
4	R07-R11	Flange	1400	14000
5	R12-R15	Elbow	1200	12000
6	R16-R18	Bulb Lamp	600	6000
7	R19-R20	Stud-Bolt	400	4000
8	R21-R22	U-Bolt	240	2400
	Total		**10800**	**108000**

4.10 Storage Area to Door Distance

Area placement is based on the type of material with the highest frequency or material that often comes out, which is placed close to the entrance/exit. Travel distance for material handling is measured from the door (I/O) to the storage area, using the Rectilinear Distance method. The distance is measured along the path using lines perpendicular (orthogonal) to each other to the point of each storage area using the following formula:

$$d_{ij} = |x-a| + |y-b|$$

Description:
dij = distance from facility i to facility j
x = distance of the center point of facility i to the x-axis (horizontal)
a = distance of the center point of facility j to the x-axis
y = distance of the center point of facility i to the y-axis (vertical)
b = distance of the center point of facility j to the y-axis

The results of the storage-to-door distance calculation are shown in Table 9.

Table.9 Storage Distance to Door

No	Storage Area	Distance to Storage Area (m)
1	R01	4
2	R02	7
3	R03	10
4	R04	13
5	R05	16
6	R06	7
7	R07	10

No	Storage Area	Distance to Storage Area (m)
8	R08	13
9	R09	16
10	R10	19
11	R11	10
12	R12	13
13	R13	16
14	R14	19
15	R15	22
16	R16	13
17	R17	16
18	R18	19
19	R19	16
20	R20	19
21	R21	22
22	R22	19

Sumber: PT.XYZ

In the shared storage method, storage areas are identified and coded in order of the closest empty area to the entrance, starting from the closest to the farthest. Once these locations are determined, distance measurements are taken and grouped based on proximity to the entrance to create an optimal warehouse layout design. The purpose of this proposed layout is to speed up the picking of materials, especially those with high demand, by arranging items in order, so that picking becomes more effective and efficient, reducing the time required, and improving employee performance. Therefore, this distance analysis not only makes it possible to determine more strategic storage locations, but also supports a more organized and efficient workflow throughout the warehouse operations.

5 CONCLUSION

Based on the results of the discussion, the following conclusions are obtained:

1. By using the shared storage method, the proposed improvements to the material storage layout at PT.XYZ can optimize storage capacity and facilitate material retrieval, thereby speeding up the operational process in the warehouse.
2. After the new warehouse layout design is proposed, calculations are made to add shelves and assign numbers according to the type of material. Two storage racks were added and arranged parallel to the existing rack position.

Initially, there were 9000 boxes/racks, after the changes the number increased to 10800 boxes/racks.

3. In the old layout there were 20 storage racks. After doing the calculation, the rack capacity was increased and arranged in a number consisting of 2 to 3 storage sections, namely R01-R02, R03-R04, R05-R06, R07-R08, R09-R10, R11-R12, R13-R14, R15-R17, R18-R20, and R21-R22. The most requested materials are placed near the storage door to make it easier to take the materials out.
4. The advantage of the shared storage method in the PT.XYZ warehouse is to arrange several types of materials sequentially in one area, which can improve the efficiency of warehouse space utilization. With this method, frequently requested materials can be placed closer to the entrance, thus speeding up material retrieval.

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