Redesign of finished goods warehouse storage layout using the shared storage method to increase capacity and minimize time with a simulation approach

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ABSTRACT

Warehouse PT. XYZ is experiencing over-capacity due to the inability to accommodate the goods that continue to increase. This is due to the warehouse arrangement that only utilizes floor stakes so that it takes up horizontal space with the use of 1.2 m x 1.2 m pallets. This makes warehouse utilization low by 17.93%. This study aims to increase pallet storage capacity and minimize product search time by using the shared storage method and designing a simulation model using the layout on pro model 7.6 software. The results of this study are an increase in storage capacity to 54 pallets, an increase in warehouse utility by 40% to 60.02%, and reduce the material transfer distance to 155.10 m. This affects the product retrieval time which can be reduced to 2.5 minutes from 7.61 minutes in the initial layout to 5.11 minutes.

Keywords: Capacity, Layout, Shared Storage, Simulation, Pro model 7.6

1. Introduction

PT XYZ is a company engaged in manufacturing by producing innovative sharp box products for sharp medical waste. Currently, the company is in the growth stage. The company always evaluates and improves the product so that the product has an increase in sales and the increasing intensity of the company's production. A production system with a make-to-stock system is applied so that it has a high risk related to inventory investment because actual customer orders cannot be identified correctly in the production process. However, the strategy implemented by the company has not been maximized so it creates problems for the company. This is evidenced by the number of product stocks that exceed the warehouse capacity.

According to [1] a warehouse is a separate area for storing raw materials, and parts for availability. The survey stated that the warehouse not only has a large area but can also accommodate all the goods produced as much as possible. The main concern in the warehouse layout is efficiency and effectiveness in the entry and exit of goods in the warehouse.

The warehouse with an area of 76.69 m² stores products in the form of inner boxes, and full sets of sharp boxes. The dimensions of the inner box are 0.21 x 0.21 x 0.21 m and the outer box is 0.235 x 235 x 0.265 m. The product storage process in the warehouse only utilizes floor stakes with one level stored using pallets with dimensions of 1.2 m x 1.2 m with a height of 1.8 m and based on company policy for inner storage with a maximum of 12 stacks and outer 4 stacks. This causes an overcapacity in the warehouse so that the capacity cannot be fulfilled by the inventory in the warehouse.
Figure 1. Capacity and Product Comparison Diagram

Based on Figure 1 there is an excess capacity of goods that cannot be accommodated in the warehouse and then temporarily placed in available spaces such as quarantine rooms and production rooms. Meanwhile, the slow movement of goods causes a buildup of goods in the warehouse.

The utility of the space used is only 17.93%, and the pallet capacity that is accommodated is 23. With such a low utility, the utilization of the warehouse is not optimal because according to [2] the maximum storage is in a warehouse with a large size of 80% with 20% used for the aisle. In arranging the layout of the warehouse, a good and correct storage policy is not implemented. The products are stored in the available space regardless of whether the surrounding products are the same product or not, so that the product are mixed. The warehouse area is used without taking into account the use of the right storage area, making the warehouse capacity not used optimally and its storage capacity decreases.

The current layout of the warehouse also has an impact on order picking processing with a tendency to be slower due to the difficulty of the picker in finding the right goods to be sent, so it is necessary to have a layout redesign for the warehouse using the shared storage method to increase pallet storage capacity and minimize product search time. The shared storage method is used in the design of simulation modeling in layouts assisted by pro model 7.6 software.

2. Materials and Methods
3. Results and Discussion

3.1 Existing Layout

3.1.1 Warehouse Utilization

Space Utility = \( \frac{\text{Total Area Of Use}}{\text{Room Area}} \times 100\% \)

= \( \frac{61,616 \text{ m}^2}{343,6 \text{ m}^2} \times 100\% \)

= 17.93 %

3.1.2 Mileage

Table 1 Mileage MH

<table>
<thead>
<tr>
<th>Blok</th>
<th>Distance</th>
<th>Product</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>4.93</td>
<td>Outer Box</td>
<td>7</td>
</tr>
<tr>
<td>B</td>
<td>10.22</td>
<td>Inner Box</td>
<td>7</td>
</tr>
<tr>
<td>C</td>
<td>4.93</td>
<td>Outer Box</td>
<td>7</td>
</tr>
<tr>
<td>D</td>
<td>3.64</td>
<td>Inner Box</td>
<td>7</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Based on the data in Table 1, the data is normally distributed with the smallest Anderson-Darling Test value and the largest correlation coefficient. Validation testing will be carried out using a parametric test, namely the t-test.

3.1.4 Data Sufficiency Test

The data adequacy test is carried out with a 95% confidence level, so the value is 5%. To be able to calculate N', the confidence index (k) must be determined using the distribution table. \( Z \approx 2 = Z_{0.025} = 1.96 \) so the confidence index to be used is 2. Furthermore, the accuracy level index (s) is = 0.05.

\[
N' = \left( \frac{k}{s} \sqrt{N \sum(x^2) - (\sum x)^2} \right)^2
\]

\[
N' = \left[ \frac{2}{0.05} \sqrt{7.457.7 - (320.13)} \right]^2
\]

\[
N' = 1.29^2
\]
The results of the adequacy test show that N'<N so that the minimum amount of data is sufficient.

3.1.5 Verification and Validation

The verification process is carried out to find out whether the model runs according to the process in real conditions and to find out whether an error occurred when running the simulation. The verification process is carried out by observing when simulating to see if the model can imitate according to the logic being executed and checking the results of the running simulation.

Figure 4 Initial Simulation Running Results

The results of running the existing layout simulation with an average time in system output are obtained in the entity states section. After the verification process is carried out, the next validation process is in which in this process the model can interpret the real system.

Table 3 Paired Sample Test Results

<table>
<thead>
<tr>
<th>Replication</th>
<th>Average time in system (minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7.52</td>
</tr>
<tr>
<td>2</td>
<td>8.08</td>
</tr>
<tr>
<td>3</td>
<td>7.11</td>
</tr>
<tr>
<td>4</td>
<td>7.49</td>
</tr>
<tr>
<td>5</td>
<td>8.82</td>
</tr>
<tr>
<td>6</td>
<td>7.14</td>
</tr>
<tr>
<td>7</td>
<td>7.13</td>
</tr>
<tr>
<td>Mean</td>
<td>7.61</td>
</tr>
<tr>
<td>Stdev</td>
<td>0.634</td>
</tr>
</tbody>
</table>

Half-width $= \frac{(t_{n-1})s}{\sqrt{n}}$

Half-width $= \frac{2.447 \times 0.634}{\sqrt{7}}$

$= 0.58 \approx 1$

Furthermore, the value of half width is obtained with the stages of determining the error value in minimizing errors in presenting the real system. desired error 0.5

$n' = \left( \frac{Z_{\alpha/2}s}{e} \right)^2$

$n' = \left( \frac{(1.96) \times 0.624}{0.5} \right)^2$

$= 5.96 \approx 6$

Based on the calculation of the replication that the total replication in the research conducted is required with the number of 6 replications.
3.2 Proposal Layout

3.2.1 Calculation of Space Requirements

\[
\text{Area Requirement} = \frac{\text{Storaged Average}}{\text{Storage Capacity}}
\]

Outer Area = \(\frac{4.850}{64} = 75.78 \approx 76 \approx 11\)

Inner Area = \(\frac{13,000}{300} = 43.33 \approx 44 \approx 7\)

3.2.2 Storage area

Area = \(\text{Length} \times \text{Width of Pallet}\)

= \(120 \text{ cm} \times 120 \text{ cm}\)

= \(14,400 \text{ cm}^2 = 1.44 \text{ m}^2\)

Outer area requirement = \(11 \times 1.44 \text{ m}^2\)

= \(15.84 \text{ m}^2\)

Inner area requirement = \(7 \times 1.44 \text{ m}^2\)

= \(10.08 \text{ m}\)

3.2.3 Aisle Width

\[
\text{Aisle width} = \sqrt{(\text{Length}^2) + (\text{width}^2)}
\]

= \(\sqrt{(1.35^2) + (0.55^2)}\)

= \(\sqrt{2.125} = 1.4 \text{ m}^2\)

3.2.4 Throughput

\[
T = \frac{\text{Rata rata barang masuk}}{\text{Jumlah kemasi dalam 1 pallet}} \times \frac{\text{Rata rata barang keluar}}{\text{Jumlah kemasi dalam 1 pallet}}
\]

\[
T_{\text{Outer}} = \frac{4.850}{64} + \frac{4.950}{64} = 153.125
\]

\[
T_{\text{Inner}} = \frac{13,000}{300} + \frac{12,854}{300} = 86.18
\]

3.2.5 Assignment

\[
\text{Assignment} = \frac{\text{Throughput}}{\text{Space Requirement}}
\]

\[
\frac{T_{\text{Outer}}}{11} = 13.92
\]

\[
\frac{T_{\text{Inner}}}{7} = 12.31
\]

3.2.6 Warehouse Arrangement

The current condition of the warehouse is still implementing floor stakes, so the proposal that will be given is to use a racking-type warehouse to increase warehouse capacity and expand storage capacity. The shelves used in this warehouse proposal are \(4.4 \text{ m} \times 1.24 \text{ m} \times 4.5 \text{ m}\).

Figure 5 Shelf Specification

The racks will be arranged according to the warehouse capacity which can only accommodate 6 shelves filled with 54 pallets.
Product storage is placed based on the largest assignment value with the closest distance to the I/O door. The calculations that have been carried out in the previous sub-chapter require 18 areas consisting of 11 areas for the outer box and 7 areas for the inner box while the aisle width is 1.4 m. Then the proposed layout can be seen in Figure 3.4

3.2.7 Calculation of Storage Distance between I/O Doors

![Figure 6 Shelf Specification](image)

Rectilinear distance \(= \sqrt{(x - a)^2 + (x - b)^2}\)

<table>
<thead>
<tr>
<th>Area</th>
<th>Distance (m)</th>
<th>Area</th>
<th>Distance (m)</th>
<th>Area</th>
<th>Distance (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>3.35</td>
<td>A7</td>
<td>5.70</td>
<td>B2</td>
<td>9.78</td>
</tr>
<tr>
<td>A2</td>
<td>2.92</td>
<td>A8</td>
<td>5.46</td>
<td>B3</td>
<td>9.64</td>
</tr>
<tr>
<td>A3</td>
<td>3.99</td>
<td>A9</td>
<td>6.10</td>
<td>B4</td>
<td>10.01</td>
</tr>
<tr>
<td>A4</td>
<td>4.44</td>
<td>A10</td>
<td>8.37</td>
<td>B5</td>
<td>11.19</td>
</tr>
<tr>
<td>A5</td>
<td>4.12</td>
<td>A11</td>
<td>8.21</td>
<td>B6</td>
<td>11.37</td>
</tr>
<tr>
<td>A6</td>
<td>4.94</td>
<td>B1</td>
<td>8.65</td>
<td>B7</td>
<td>11.40</td>
</tr>
</tbody>
</table>

3.2.8 Displacement Distance Calculation Material Handling

Table 3 Proposed Handling Material Transfer Distance

<table>
<thead>
<tr>
<th>Block</th>
<th>Distance</th>
<th>Product</th>
<th>T/S</th>
<th>Space Requirement</th>
<th>Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>2.90</td>
<td>Outer Box</td>
<td>14</td>
<td>11</td>
<td>40.6</td>
</tr>
<tr>
<td>B</td>
<td>9.23</td>
<td>Inner Box</td>
<td>12</td>
<td>7</td>
<td>110.8</td>
</tr>
</tbody>
</table>

3.2.9 Warehouse Utility Calculation

Utilities \(= \frac{\text{Total Area Of Use}}{\text{Room Area}} \times 100\%\)

\(= \frac{206.24 \text{ m}^3}{343.6 \text{ m}^3} \times 100\%\)

\(= 60.02\%\)

A Comparison of the initial and proposed layouts is carried out after designing the proposed layout and simulating the two models. Warehouse capacity can be increased by writing in table 4.7

Table 4 Layout Comparison

<table>
<thead>
<tr>
<th>Layout</th>
<th>Capacity</th>
<th>Utilization</th>
<th>Average Time In System</th>
<th>Displacement Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing layout</td>
<td>23 Pallet</td>
<td>17.93%</td>
<td>7.61</td>
<td>166.09 m</td>
</tr>
<tr>
<td>Proposed Layout</td>
<td>54 Pallet</td>
<td>60.02%</td>
<td>5.11</td>
<td>151.4 m</td>
</tr>
</tbody>
</table>

As for the results of the simulation in the form of comparative output produced in the form of average time in the system with data replication seventh times, this proposed layout can reduce the time in the product search process so that it can become a reference in the company in improving its warehouse layout.

4. Conclusion

The design in implementing the shared storage method in this warehouse is carried out for the preparation of layouts based on throughput calculations and assignment values that have higher values. The outer product will be placed at the closest distance to the I/O door and the layout preparation process uses a rack system that can utilize vertical storage to optimize the height of the warehouse.

Pallet storage in the warehouse has increased so that currently the pallets that can be stored in the warehouse are 54 pallets and the
displacement of the material handling distance has decreased in the initial layout of 166.09 m while the proposed layout is 155.10 m so that the displacement distance is reduced by 10.99 m. and the simulation results from the proposed layout can reduce the average product search time for 2.5 minutes.

Reference