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
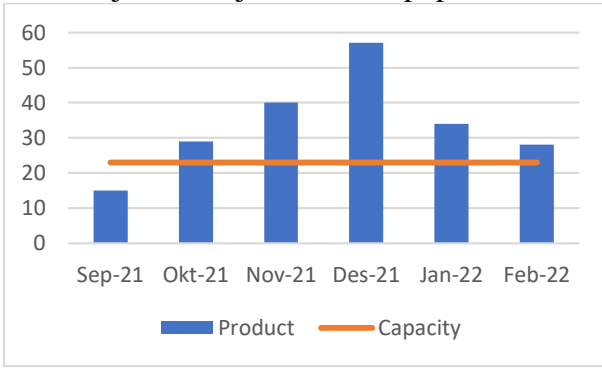
Figure 1. Capacity and Product Comparison Diagram

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.
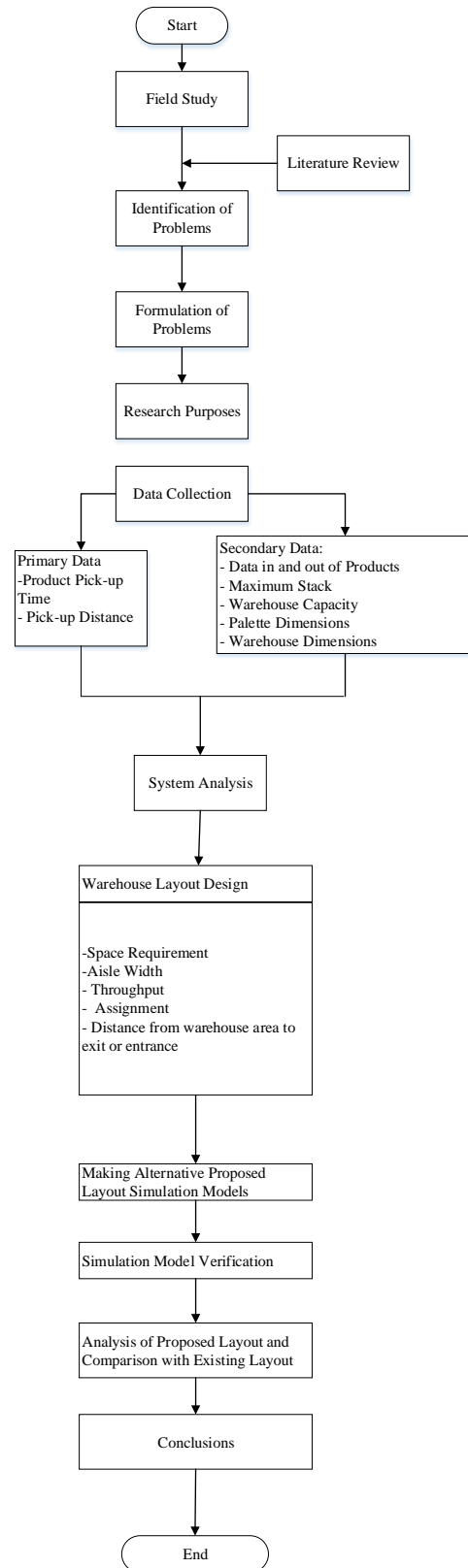
2. Materials and Methods

Figure 2 Research Flowchart

3. Results and Discussion

3.1 Existing Layout

3.1.1 Warehouse Utilization

$$\text{Space Utility} = \frac{\text{Total Area Of Use}}{\text{Room Area}} \text{x } 100\%$$
$$= \frac{61,616 \ m}{343,6 \ m^2} \text{x } 100\%$$
$$= 17.93 \ \%$$

3.1.2 Mileage

Table 1 Mileage MH

Blok	Distance	Product	Frequecy	
A	4,93	Outer Box	7	34,53
B	10,22	Inner Box	7	71,54
C	4,93	Outer Box	7	34,53
D	3,64	Inner Box	7	25,48
Total				166,09

3.1.3 Fitting Distribution
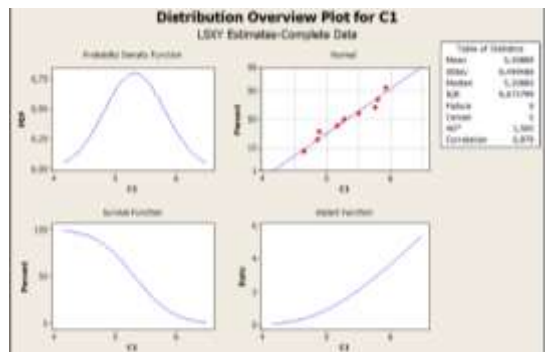

Figure 3. Data Input Results

Table 2 Fitting Distribution Data

Distribution	Anderson-Darling (adj)	Correlation Coefficient
Weibull	1,572	0,972
Lognormal	1,502	0,979
Exponential	6,958	*
Loglogistic	1,535	0,973
3-Parameter Weibull	1,501	0,985
3-Parameter Lognormal	1,500	0,979
2-Parameter Exponential	3,192	*
3-Parameter Loglogistic	1,532	0,973
Smallest Extreme Value	1,605	0,968
Normal	1,500	0,979
Logistic	1,531	0,973

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. $Z \propto 2 \diagup = Z \ 0.025 = 1.96$ so the confidence index to be used is 2. Furthermore, the accuracy level index (s) is = 0.05.

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

$$N' = \left[\frac{\frac{2}{0,05} \sqrt{7.457,7 - (3201,3)}}{56,58} \right]\mathbf{2}$$

$$N' = 1.29 \ 2$$

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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

		Paired Samples Test						
		Paired Differences						
					Interval of the			
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df
Pair 1	SIS_NYATA - SIS_MODEL	,41429	,50106	,18938	-,04912	,87769	2,188	6

Source: Data Processing

In table 3 the value of T-count < T-table is 2.188 < 2.447, for testing using Sig (2-tailed) the sig value is 0.071 > 0.05 so it can be said that there is no significant difference between the two types.

3.1.6 Determination of the Number of Replications

Table 1Product Pick-Up Time

Replication	Average time in system (minutes)
1	7,52
2	8,08
3	7,11
4	7,49
5	8,82
6	7,14
7	7,13
Mean	7,61
Stdev	0,634

Half-width $= \dfrac{\left(t_{n-1,\frac{\alpha}{2}}\right).s}{\sqrt{n}}$

Half-width $= \dfrac{2,447 \ x \ 0,634}{\sqrt{7}}$

$= 0.58 \approx 1$

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 ' $= \left[\dfrac{\left(Z_{\frac{\alpha}{2}}S\right)}{e}\right]2$

n ' $= \left[\dfrac{(1,96)x0,624}{0,5}\right]2$

$= 5,96 \approx 6$

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

Area Requirement $=\dfrac{\text{Storaged Average}}{\text{Storage Capacity}}$

Outer Area $= \dfrac{4.850}{64} = 75,78 \approx 76 \approx 11$

Inner Area $= \dfrac{13.000}{300} = 43,33 \approx 44 \approx 7$

3.2.2 Storage area

Area $=$ Length x Width of *Pallet*

$= 120$ cm x 120 cm

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

Outer area requirement $= 11$ x 1.44 m^2

$= 15.84 \text{ m}^2$

Inner area requirement $= 7$ x 1.44 m^2

$= 10.08$ m

3.2.3 *Aisle* Width

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*

$T = \dfrac{\text{Rata rata barang masuk}}{\text{jumlah kemasan dalam 1 pallet}} + \dfrac{\text{Rata rata barang keluar}}{\text{jumlah kemasan dalam 1 pallet}}$

T Outer $= \dfrac{4.850}{64} + \dfrac{4.950}{64}$

$= 153.125$

Inner T $= \dfrac{13.000}{300} + \dfrac{12.854}{300}$

$= 86,18$

3.2.5 *Assignment*

Assignment $= \dfrac{\text{Throughput}}{\text{Space Requirement}}$

Assignment outer $= \dfrac{153,125}{11}$

$= 13,92$

Assignment inner $= \dfrac{86,18}{7}$

$= 12,31$

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 m x 1.24 m x 4.5 m.
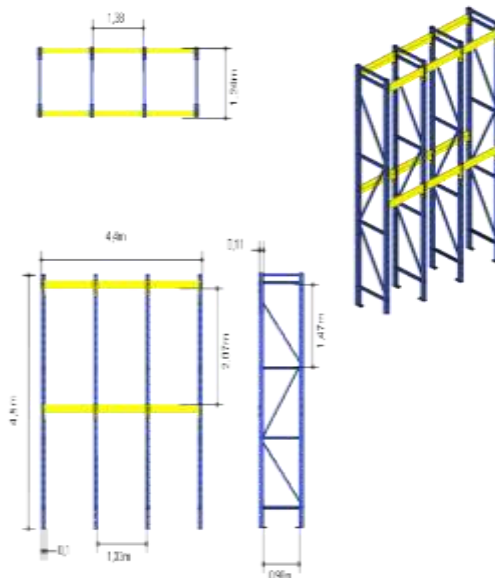

Figure 5 Shelf Specification

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

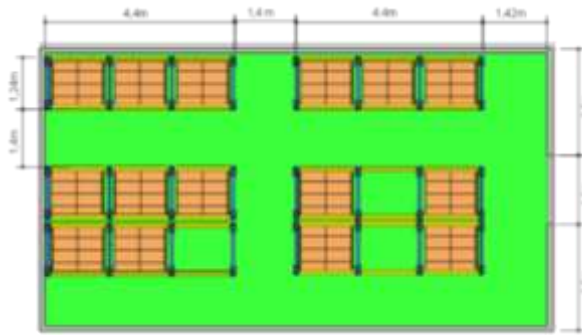### 3.2.7 Calculation of Storage Distance between I/O Doors

Figure 6 Shelf Specification

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

Table 2 Distance Between Storage and I/O Door

Area	Distance (m)	Area	Distance (m)	Area	Distance (m)
A1	3,35	A7	5,70	B2	9,78
A2	2,92	A8	5,46	B3	9,64
A3	3,99	A9	6,10	B4	10,01
A4	4,44	A10	8,37	B5	11,19
A5	4,12	A11	8,21	B6	11,37
A6	4,94	B1	8,65	B7	11,40

3.2.8 Displacement Distance Calculation Material Handling

Table 3Proposed Handling Material Transfer Distance

Blok	Distance	Product	T/S	Space Requirement	Distance
A	2,90	Outer Box	14	11	40,6
B	9,23	Inner Box	12	7	110,8
Jarak					151,4

3.2.9 Warehouse Utility Calculation

Utilities $= \dfrac{\text{Total Area Of Use}}{\text{Room Area}} \text{x } 100\%$

$= \dfrac{206,24 \ m^3}{343,6 \ m^3} \text{x } 100\%$

$= 60.02 \ \%$

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 4Layout Comparison

Layout	Capacity	Utilization	Average Time In System	Displacement Distance
Existing layout	23 Pallet	17,93%	7,61	166.09 m
Proposed Layout	54 Pallet	60,02%	5,11	151,4 m

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 is 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.

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