Warehouse Layout Designing of Cable Manufacturing Company using Dedicated Storage and Simulation Promodel

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Abstract. PT. XYZ is a cable manufacturing company that has several types of cables produced. Goods produced are stored in finished goods warehouses with two types of packaging, namely haspel and roll. Laying of goods in open goods warehouses in the form of randomly arranged haspels is mixed between each type of haspel. The purpose of this study was to evaluate the layout of finished goods warehouses for haspel types so that they can be grouped and minimize displacement time. This study uses a simulation design that is implementing a real system using a ProModel simulation and provides improved layout evaluation with a dedicated storage method approach, i.e. goods or materials placed in a fixed location. The first step is to collect and identify the real system and then implement using a ProModel simulation resulting in a total displacement time of 140.27 hours. Improvements to the layout of the finished goods warehouse using a dedicated storage method to group haspels. From the calculation results, there are two scenarios, the first is the application of haspel grouping from the calculation of a dedicated method with displacement time of 139.21 hours and the second scenario adds material handling from the first scenario, the displacement time is 128.08 hours. The results of scenario two resulted in a decrease in displacement time of 8.69% by grouping the haspel and adding material handling.

Keywords: warehouse layout, simulation, dedicated storage, displacement time

1. Introduction

PT. XYZ is a company engaged in the field of cable production which produces various types of cables such as electric cables, communication cables, and others. The cables are stored in a warehouse in an open or closed area. The area of finished goods warehouse is 15.456 m² while the area of finished goods warehouse is 3.228 m². Large cables are wound in a haspel and stored in a finished goods warehouse in an open area. While small sized cables are rolled using a roll and stored in a finished goods warehouse in an enclosed area Haspel used was haspel of wood, namely haspel a construction made of wood and iron as reinforcement.

The warehouse is a supporting facility that has an important role in the production system [1], [2] [3]. There are many factors that influence warehouse design, such as order picking methods, size, and layout of the storage system, material handling systems, product characteristics, demand trends, turnover rates and space requirements [4]. Based on the results of a literature study [5] warehouse
performance measurement can be measured from 5 size dimensions namely time, quality, cost and productivity.

The focus of this research is on finished goods warehouses in open areas. The finished goods warehouse in an open area is divided into six areas namely A1, A2, A3, A4, A5 and A6. The type of haspel that is stored in the warehouse area consists of 27 types of haspels with different types of sizes (H50, H55, H60 etc.). However, haspel storage in that area has not been classified by type. Laying of items that are still mixed, not grouped. This causes a long time to search for goods in the warehouse. In addition, the location of laying the warehouse is far from the location of packing or shipping. Haspel transfer activity is carried out by using a forklift.

Based on these problems, it is necessary to arrange the product storage location in the finished product warehouse. This study aims to design a simulation model of finished goods warehouse with a dedicated storage method. This method can provide solutions in the preparation of products in the warehouse to optimize the use of the area available in the warehouse [2]. Class-based storage methods can also increase productivity in processes in the warehouse, such as reducing the time of material uptake and the distance of uptake [4]. Thus it can be known how much it actually needs the area required by the finished product warehouse.

Evaluation of layout improvement is simulated with Promodel discrete event simulation software. Modeling is a windows based system with an intuitive graphical interface and object oriented modeling construct [6]. Promodel is also powerful as a simulation tool for solving manufacturing and service system problems [7], [8] and [6]. Previous studies that have been conducted related to simulations [9] and [10], [11] Succeeded in using the dedicated storage method to replace items that were mixed in a place and arranged according to the category and consideration of the activities of the goods. This method is used to classify goods in a fixed place and not change again. This research will produce the usual warehouse layout design for open areas and the evaluation of proposals will be simulated using a promodel.

2. Methods
Data collection was done through interviews with the operator and the head of the warehouse of finished goods to find out which activities in the warehouse, the method of placement haspel and retrieval haspel in warehouse. Direct observation to observe activity in finished goods warehouse and measure the time displacement. Historical Data the required data include the type of haspel, the data of exit and entry haspel, and the frequency of the displacement haspel. The instruments used in this study include 1) interview guidelines; 2) Observation sheet; 3) field notes and stationery to record interview results; 4) recording device was used to record all interactions and communications that were not recorded in the study. In this study there were 5 stages in conducting, namely:
1. Analysis of existing system. The system analyzed is the layout system of finished product warehouses in the outside area.
2. Designing the simulation model layout of the warehouse at this time.
   a. Simulation models consist of structural elements, operational and numerical data.
   b. Testing the distribution of simulation input data using Stat fit.
   c. Running simulation using Promodel.
   d. Verification and validation.
3. Improved layout of the warehouse of finished goods used methods dedicated storage.
   Improvement of warehouse layout used dedicated storage method:
   a. Calculate space requirement for every haspel.
   b. Calculate Floor Space Requirements for every haspel.
   c. Rank the biggest T/S value to the smallest.
   d. Calculate total distance traveled.
   e. Haspel placement.
4. Evaluation of scenario improvement of warehouse layout using simulation Promodel.
5. In selecting the warehouse layout proposal ANOVA and Least Significant Different (LSD) calculations are performed to compare the proposed model with the initial system model conducted in this study the analysis of the results of the improved layout of the warehouse of finished goods.

3. Result and Discussion

3.1. Analysis System

Warehouse of finished goods on the open area is divided into 6 storage areas, namely A1, A2, A3, A4, A5 and A6. This warehouse saves the 27 types of haspel with a variety of sizes. Distribution of types of haspel on each area is done randomly. The laying of the haspel is still often mixed with each other, not grouped by type. This has an impact on the search time items long. Warehouse layout can currently be seen in Figure 1. In Figure 1 it can be seen that the finished goods warehouse is divided into several areas which are given a different colour and each area of the contents by some kind of haspel. The arrow explains the flow of the movement of goods in the warehouse. Arrow coloured orange explaining the transfer of goods from packing to storage area and green from the storage area to the shipping.

![Image 1](current_layout.png)

**Figure 1. Current Layout of the Goods Warehouse**

The sequence of flow of activities that occur on the warehouse of finished goods PT. XYZ can be seen in Figure 3.

![Image 2](haspel_stack.png)

**Figure 2. Haspel stack**

![Image 3](flow_process.png)

**Figure 3. The flow of the Transfer Process of Finished Goods in the Warehouse of PT XYZ**
3.2. Designing a Simulation Model with Promodel

Building a credible and valid simulation model requires specific steps to be followed [12]. The division of the elements simulation based on the perspective of simulation using Promodel can be seen in Table 1 (Structural element) and Table 2 (Operational element).

Table 1. Structural Elements Simulating a Warehouse Layout System

| Element       | Definition                              | Element in system                          |
|---------------|-----------------------------------------|--------------------------------------------|
| Entities      | All this that participate in the system.| Consist of 27 types of Haspel (Haspel 50,  |
|               |                                         | Haspel 55, etc.)                           |
| Location      | The place or location where the entity   | Area A1, A2, A3, A4, A5, A6, Shipping,    |
|               | is processed                            | Packing                                    |
| Resource      | Resources used to carry out the process | Material handling equipment (3 forklift)   |
| Path Network  | The path through which entities in the   | The route used material handling in         |
|               | system                                  | warehouse of finished Goods                |

Table 2. Operational Elements Simulating a Warehouse Layout System

| Element     | Definition                              | Element in system                          |
|-------------|-----------------------------------------|--------------------------------------------|
| Arrivals    | The arrival of entities in the system   | The arrival of the goods into the warehouse, with input form the number of items in the Qty Each |
| Processing  | The process carried out in the system   | The process observed is the movement of finished goods from packing to area and area to shipping |

Output variables in this research consist of two variables, namely the total time of displacement and the utility of material handling. The total time displacement in this study was defined as the total time of retrieval of the goods and the transport that occurs in the warehouse of finished goods for one month.

Distribution testing in this study used the Stat: fit application. Distribution testing was carried out to determine the suitability of the data with the type of distribution. The results of processing stat: fit data for Area A1 can be seen in Table 3.

Table 3. Summary of Probability Distribution for Area 1

| #  | Name                                    | Distribution | Expression           |
|----|-----------------------------------------|--------------|----------------------|
| 1  | Receiving time from packing to A1       | Lognormal    | 0.765+L(0.563, 0.179) |
| 2  | Order picking time Haspel 50            | Lognormal    | 0.765+L(0.563, 0.179) |
| 3  | Order picking time Haspel 55            | Uniform      | U(1.33, 0.3)        |
| 4  | Order picking time Haspel 60            | Lognormal    | 0.284+L(1.07, 0.178) |
| 5  | Order picking time Haspel 70            | Uniform      | U(1.36, 0.31)       |
| 6  | Order picking time Haspel 80            | Uniform      | U(1.39, 0.3)        |
| 7  | Shipping time from A1 to Shipping       | Lognormal    | 0.714+L(0.376,5.e-002) |

Verification of the model used two methods, namely the Verification of the model with the Bottom-Up and verification of the model with the facility trace at Pro Model. The results of the verification showed that the model simulation of the same system actually. Replication was performed five times with the value of half width which is desired by 0.1 and \( Z_{0.025} = 1.96 \).

Model validation based on the comparison of the displacement time taken from the multiplication of % in use of material handling with the total time of the simulation. The next stage was to compare the simulation results with a time displacement using material handling in a real system (Table 4).
Table 4. System Validation

| Use of Material Handling | Replacement Time of the Haspel (minutes) | Time difference |
|--------------------------|----------------------------------------|----------------|
|                          | Real System | Simulation |                      |
| Forklift 1               | 3213.41     | 3587.83    | -374.41               |
| Forklift 2               | 3272.05     | 3298.31    | -26.25                |
| Forklift 3               | 3253.09     | 4202.21    | -949.13               |

Based on the results and the calculation of half width, obtained interval value as follows:

\[-1607.47 \leq \mu ((1-2)) \leq 707.61\]  

(1)

From the results of the interval it can be seen that there is a hose between the interval that has been calculated and the interval includes the numbers 0. Under these conditions it can be concluded that $H_0$ is accepted, then the results of the real system and the simulation system is otherwise the same.

3.3. Improvement of Warehouse Layout using the Method Dedicated Storage

The results of the improvement of warehouse layout used the method of dedicated storage was as follows:

1. **Calculate Space Requirement for every Haspel**
   In this calculation it was assumed one Block can fit at 3.5 m$^2$ taken from the largest dimensions of haspel, namely haspel 50.
   
   Space requirement Haspel 50 = \( \frac{\text{Maximum storage requirements of each product}}{\text{storage capacity}} \)  
   
   \( = \frac{11}{19} \approx 1 \text{ Slot} \)  
   
   An example of the calculation of the floor area haspel 50:
   
   Floor area requirements haspel 50 = Space requirements x product dimensions  
   
   = (1 x 3.5) = 3.5 m$^2$

2. **Calculate Throughput for every Haspel**
   The calculation of the throughput to determine the amount of activity the storage and delivery of finished goods in the period of one month.
   
   \[ T = \frac{\text{average reception activity / day}}{\text{number of transfers at one time}} + \frac{\text{average shipping activity per day}}{\text{number of transfers at one time}} \]  
   
   \[ = \frac{0.8}{1} + \frac{0.8}{1} = 1.67 \text{ activity} \]  

3. **Rank the biggest T/S Value to the smallest**
   To determine the laying of the goods, it used the comparison between the throughput and storage. The calculation of the placement of goods so use the following formula:
   
   Placement of finished goods: haspel 50 = \( \frac{\text{throughput}}{\text{space requirement}} \)  
   
   \( = \frac{1.67}{1} \approx 1 \)  

4. **Calculate Distance ever Block to I/O**
   The calculation of the distance of travel of the material handling is done by using the method of rectilinear distance. This calculation is taken from the center point of the storage area and a middle area packing and shipping and for the input and the output. Calculation Results with the Dedicated Storage Method can be seen in Table 5.

5. **Product Placement**
   Product placement in Table 6 is done by putting a product that has a high T/S on the location with the closest distance to the input-output, and next put the smallest T/S on the location with the next closest distance to the input-output, and so on.
Table 5. Calculation Results with the Dedicated Storage Method

| No | Haspel type | Maximum receipt of finished goods (unit) | Haspel dimension (m²) | Capacity / block (unit) | Space requirement calculation (block) | Dimension / block (m²) | The calculation of floor space requirements (m²) | Throughput of area | The average receipt per month (unit) | The average delivery per month (unit) | Throughput (T) | T/S comparison | Distance calculation |
|----|-------------|-----------------------------------------|----------------------|------------------------|--------------------------------------|------------------------|-----------------------------------------------|------------------|--------------------------------------|-------------------------------|----------------|----------------|----------------------|
| 1  | 50          | 11                                      | 0.18                 | 19                     | 1                                    | 3.5                    | 3.5                                           | 0.80             | 0.87                  | 1.67                          | 1.67            | 46.15          |                      |
| 2  | 55          | 13                                      | 0.21                 | 16                     | 1                                    | 3.5                    | 3.5                                           | 1.10             | 0.90                  | 2.00                          | 2               | 46.15          |                      |
| 3  | 60          | 44                                      | 0.25                 | 14                     | 4                                    | 3.5                    | 1.4                                           | 4.97             | 3.23                  | 8.20                          | 2.05            | 46.15          |                      |
| 4  | 70          | 8                                       | 0.30                 | 11                     | 1                                    | 3.5                    | 3.5                                           | 1.27             | 0.60                  | 1.87                          | 1.87            | 46.15          |                      |
| 5  | 80          | 15                                      | 0.39                 | 9                      | 2                                    | 3.5                    | 7                                               | 2.27             | 1.90                  | 4.17                          | 2.09            | 46.15          |                      |

Table 6. Product placement

| Area | Haspel type | Distance (m) |
|------|-------------|--------------|
| A1   | H50, H55, H60, H70, H80 | 46.15        |
| A2   | H90, H95, H100     | 16.48        |
| A3   | H101, H110, H111, H120 | 62.57        |
| A4   | H125, H130, H140   | 118.37       |
| A5   | H150, H160, H170   | 12.24        |
| A6   | H180, H190, H200, H201, H210, H211, H230, H241, H250 | 76.41        |

Figure 4. Proposed Improvement of Warehouse Layout with Dedicated Storage Method

With the calculation of the dedicated storage obtained some changes in the location of the laying of the goods in the warehouse. By applying such methods, there are some changes the location of the laying of the goods in the warehouse like Figure 3.

3.4. Scenarios for Improvement of Layout of Product Warehouse

The design of the scenarios is made to determine the possibilities of repair solutions warehouse layout. In this research produced two improvement scenarios layout.

1. Scenario 1
   Scenario 1 is the result of an improved warehouse layout based on the dedicated storage method. From the calculation results of the method for each type of haspel has a specific area and is not mixed by other haspels. The application of the results of these methods results in a time of goods movement of 139.394 Hours.

2. Scenario 2
   The second scenario uses item laying calculations like scenario one with the addition of material handling units. The addition of material handling is done on material handling which has the
highest% in use. The material handling that was added was found in forklift 1 which became 2 units. Simulation results show the time of moving goods in the warehouse of 128.145 hours.

Figure 5. Warehouse Layout Simulation Model Scenario 1

3.5. Evaluation of The Proposed Improvement Warehouse Layout

The key performance indicator used to evaluate the results of warehouse layout improvements is the time of movement. The results obtained from the simulation of taking goods are different for each proposed improvement and decreased which can be seen in Table 7.

| Replication | Displacement time of the Haspel (minutes) |
|-------------|-------------------------------------------|
|             | Existing | Scenario 1 | Scenario 2 |
| 1           | 140.27   | 139.21     | 128.08     |
| 2           | 140.28   | 139.33     | 128.21     |
| 3           | 140.57   | 139.19     | 127.93     |
| 4           | 140.41   | 139.54     | 128.04     |
| 5           | 140.60   | 139.54     | 128.82     |
| Mean        | 140.49   | 139.39     | 128.22     |

Based on the results of the calculation of the ANOVA test obtained value of F count equal to 3484.29 and F table of 3.89. If F count > F table then H0 is rejected. H0 used is there a significant difference between the average system output current simulation and proposal. F count is greater than the F table so that H0 is rejected which means that there is a significant difference against the average output of the simulation system at this time and the proposal. After doing the ANOVA test carried out advanced test that test the methods of LSD to see the differences can be seen in Table 8.

| Treatment | mean | Treatment | mean | Score different | Result               |
|-----------|------|-----------|------|-----------------|----------------------|
| Existing System | 140.49 | Scenario 1 | 139.39 | 0.35 | significantly different |
| Scenario 1 | 139.39 | Scenario 2 | 128.15 | 0.35 | significantly different |

Table 9. Comparison Results of Initial Models and Proposed Models

| Model      | Displacement time (hour) | percentage decrease in time |
|------------|--------------------------|-----------------------------|
| Initial layout | 140.27                   |                             |
| Scenario 1  | 139.21                   | 0.75%                       |
| Scenario 2  | 128.08                   | 8.69%                       |
The results of comparison of the proposed model with the initial model can be seen in Table 9. From the results of the comparison table of the initial model and the proposed model it can be seen that for the proposed model 1 decreased by 0.75% and the proposed model 2 decreased by 8.69%. So the proposed model 2 is the best proposed model.

4. Conclusion

In this paper compiled several conclusions, namely:

The simulation results using Promodel on the current warehouse layout produce a product transfer time of 140.27 hours in a month. This research has produced two proposed improvements. The first scenario results in an improved warehouse layout using the dedicated storage method. 27 Types of Haspel in warehouses are grouped into 6 areas based on their level of activity. The second scenario results in an improvement in the first scenario plus the addition of material handling tools based on the highest percentage of utilities. The results of the evaluation with the simulation of the first scenario produce a displacement time of 139.21 hours per month while the second scenario produces a simulation time of 128.08 hours per month. The simulation output has been tested with ANOVA and LSD, the results show a significant difference between the two scenarios, so the output of the two simulations can be compared. Scenario one results in a time decrease of 0.78% and scenario two is 8.73%. The selected improvement scenario is scenario two.

The Key performance indicator used in this study is still limited on time and the utility of material handling. This research can be developed using the key performance indicator of the other, such as quality, cost and productivity. In addition, this research also has yet to calculate storage space efficiency.

5. References

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