Changes in Layout and Handling Method for Raw Materials to Reduce Put Away and Picking Time: A Plastic Packaging Manufacturer Case Study

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Abstract. This research was conducted at a plastic packaging manufacturer, where the company is required to be able to respond to customer demand from the aspect of raw materials storing process. However, the existing the warehouse is not clear. Improvement plan to reduce the put away and picking time in the raw material warehouse were conducted by changing the layout and handling method. Layout change was designed based on raw material selectivity and consumption rate with two improvement scenarios. Scenario I was designed by ignoring the area for the PET group, while scenario II was designed by determining the area for the PET group. The handling method which was originally using porters was changed to using a forklift. In the put away process, the layout change by determining the area for the PET group could decrease the travel distance of 6.96%, and the handling method change could decrease the travel time of 79.34% and total put away time of 68.84%. In the picking process, layout change by ignoring the area for the PET group could decrease in travel distance of 1.81%, and handling method change could decrease in travel time by 86.92% and total picking time of 65.86%. Based on these results, the handling method change could give better result on the decrease of put away and picking time than the layout change. By implementing this recommendation, the company could save their operational cost by the estimation of 24.03%.

1. Introduction

Customer demand is an important thing that must be considered by the company. Companies must be able to respond to these demands well such as increasing production capacity and increasing warehouse capacity to store raw materials and finished goods to meet the number of demand and increase the speed of service to customers.

The type of raw material warehouse of this case study is extended storage, where it has a function to store goods to meet demand in the coming period. The types of raw materials stored in warehouse are HDPE (High-Density Polyethylene), LDPE (Low-Density Polyethylene), PC (Polycarbonate), PET (Polyethylene Terephthalate), PP (Polypropylene), PS (Polystyrene) and supporting material. The average number of raw materials stored is 115,984 kg per month or 115 tons per month. All raw materials stored are solid and flammable. The group of raw materials for HDPE, LDPE, PC, PET, PP and PS is in the form of pellets and bulky in sack packaging with a standard packing quantity of 25 kg per sack. The group of PET raw materials has a standard packing quantity of 1,150 kg per sack and 1,100 kg per sack. The supporting material group consists of master batch and PSHI. Master batch can be in the form of granules or powders and bulky with packaging sacks and standard packing quantity.
of 25 kg per sack. PSHI is roll shaped and has a standard packing quantity of 50 kg per roll. The raw materials stored in the warehouse have a total of 322 SKUs.

This research was conducted at a plastic packaging manufacturer, where the company is required to be able to respond to customer demand well from the aspect of the process of storing raw materials. However, the existing condition of the raw material warehouse is not optimal. The storage location is mixed, does not have a clear layout and does not have a heavy duty rack, thus raw materials are stored by block stacking. The objectives of this study were to obtain the assessment results of the existing layout and handling method to the put away and picking process in the raw material warehouse; to obtain recommendations for improvements of layout and handling methods of put away and picking process in the raw material warehouse; and to obtain the estimation of put away and picking process if the recommendations are implemented.

2. Research Method
There are research that has been done about warehouse layout and picking time, such as Increasing Order Picking Performance with Sequence Optimization [1], Increasing Order Picking Performance with Sequential Converting Zone-Picking Into A Zone-Picking Network [2] and Increasing Order Picking Efficiency with ANOVA [3].

2.1. Initial Condition Assessment
This stage consists of observation and data collection (historical data and data time study). Historical data included warehouse layout, material consumption rate and storage requirements, while the time study data included put away and picking time. The work elements observed during the time study in the put away process included unloading, traveling and put away, while the picking process included searching, picking and traveling. Raw materials picking orders are divided into 2 periods.

The average of existing travel distance was obtained by measuring the distance between the unloading gate and the storage location of each raw material group, which can be seen in Table 1.

| Group    | Travel Distance (m) |
|----------|---------------------|
| HDPE     | 54.7                |
| LDPE     | 51.9                |
| PC       | 50.3                |
| PET      | 59.8                |
| PP       | 33.9                |
| PS       | 57.0                |
| Supporting Material | 59.0          |

The existing picking strategy used is “picker to goods” with “pick to order” method. In this method the workers search for the storage location of the raw material according to the picking order, travel to the storage location and pick up the raw material according to the order quantity. “Pick to order” strategy is currently used with the aim of minimizing the handling activities. There are two raw material warehouses, where warehouse I has an area of 576 m² (576 m x 32 m) and warehouse II has an area of 1008 m² (21 m x 48 m). The existing layout of raw material warehouse can be seen in Figure 1.
The existing handling method used in the process of unloading raw materials was using porters. The porters unload and carry the raw material from unloading gate to the storage slot determined by the warehouse foreman, and then raw materials are stored by block stacking. Study of put away and picking time in the raw material warehouse was conducted using the time study method. This study was carried out in the raw material warehouse where the workers perform the put away and picking process manually (without a forklift). The result was the average time (s) and speed (m/s) of each work element in put away and picking process which can be seen in Table 2.

**Table 2. Average of the existing put away and picking time**

| Process   | Work Element               | Average Time (s) | Speed (m/s) |
|-----------|----------------------------|------------------|-------------|
| Put Away  | Unloading & Put Away      | 50               | -           |
|           | Travelling                | -                | 0.44        |
| Picking   | Searching & Picking       | 1,878            | -           |
|           | Travelling                | -                | 0.27        |
2.2. Layout Designing and Handling Method Changing
The layout design was made using ABC analysis based on the raw material consumption rate. This ABC analysis determines which raw material groups will occupy the closest slots to the gate or far from the gate. The first ABC analysis was carried out to determine slot allocation for 7 groups of raw materials (PP, PET, LDPE, HDPE, PC, PS and supporting material) based on raw material selectivity and consumption rate. The second ABC analysis was conducted to determine slot allocation for each SKU based on raw material consumption rate. The handling method that was originally using porters was changed to using a forklift. The study of improved put away and picking time was carried out in the finished good warehouse where workers perform the put away and picking process using a forklift where the result can be seen in Table 3.

Table 3. Average of put away and picking time using a forklift

| Process          | Work Element           | Average Time (s) | Speed (m/s) |
|------------------|------------------------|------------------|-------------|
| Put Away/ Picking| Unloading & Put Away   | 22               | -           |
|                  | Travelling             | -                | 2.00        |

2.3. Simulation and Evaluation
The layout design was then simulated using Monte Carlo simulations by generating the random number of trip number of put away and picking process each month to obtain the total put away and picking time each month. Monte Carlo simulations are probabilistic simulations and were suitable to this study because Monte Carlo simulations are able to describe a system that has elements of probability. The simulation was carried out in 10,000 replication and the results would show whether there was an improvement of put away and picking time.

3. Result and Discussion
3.1. Simulation of Existing Raw Material Warehouse Layout
Historical data on the number of put away and picking processes per month for each SKU was prepared, and then the type of distribution of the data was determined. Then the random number was generated and replicated 10,000 times to represent the number of put away or picking processes that probably occur per month for 10,000 months according to the distribution type of each SKU. Those random numbers were then used to calculate the existing travel distance and travel time in the put away and picking processes for each SKU per month.
The trial results of existing put away and picking time of each SKU then calculated as follow:

1. Existing Put Away Travel Distance = 342,621 meter/month
   Existing Put Away Travel Time = 214.39 hours/month
   Total Existing Put Away Process = 385.09 hours/month
2. Existing Picking Travel Distance = 64,627 meter/month
   Existing Picking Travel Time = 67.55 hours/month
   Total Existing Picking Process = 1,269.33 hours/month

3.2. Raw Material Warehouse Layout Change
Based on the existing conditions, improvement was designed to decrease the put away and picking time. The improvement consisted of layout and handling methods change. There would be Selective Pallet Rack and Drive-In Rack (heavy duty racks). Selective Pallet Rack has a storage capacity of 132 pallet positions with a load capacity of 1000 kg and Drive-In Rack has a storage capacity of 1179 pallet positions. The Drive-In Rack itself is divided into 2 load capacities namely 1,329 pallet positions with a load capacity of 1,000 kg and 72 pallet positions with a load capacity of 1,200 kg. The improved raw material warehouse layout design can be seen in Figure 2.
There are 2 scenarios that would be used in designing the layout:

- The layout that was designed by ignoring areas for PET groups that require a load capacity > 1,000 kg per pallet position.
- The layout that was designed based on area for PET raw material groups. This area was specifically placed on the Drive-In Rack with 3 levels.

Layout changes were made by putting the raw material group starting from the closest location to the warehouse gate according to the order of the consumption rate per day. The number of pallet position requirements was calculated from the average number of raw materials stored in the
warehouse. The determination of storage location was divided into 2 stages, first was the determination for the raw material group and second was the determination for the raw materials sub-group. The storage location of raw material groups was based on selectivity and consumption rate. Raw material group with high selectivity was a group that had a high ratio of the number of SKUs per pallet position. High selectivity groups of raw materials would be placed in Selective Pallet Rack, while lower selectivity raw materials would be placed on the Drive-In Rack. Then the group of raw materials with a consumption rate per day would be placed near the warehouse gate. Then, the storage location for each SKU was determined based on the consumption rate per day of each SKU. The required storage and consumption rate of each raw material group can be seen in Table 4.

| Group | SKU | Required Storage (pallet position) | Consumption Rate (kg/day) |
|-------|-----|-----------------------------------|---------------------------|
| HDPE  | 12  | 349                               | 21,130                    |
| LDPE  | 4   | 63                                | 3,425                     |
| PC    | 12  | 45                                | 38,035                    |
| PET   | 2   | 70                                | 22,450                    |
| PP    | 12  | 272                               | 29,845                    |
| PS    | 2   | 17                                | 2,275                     |
| Supporting Material | 278 | 322                               | 17,033                    |

3.3. Handling Method Change
The handling method change carried out in this study begun with a change in the standard raw material amount per pallet, which was 1,000 kg per pallet. The handling method that was originally using porters was changed using a forklift. Raw materials with the same SKU that have been arranged on the pallet would be placed at Warehouse III with an area of 1,320 m² (width of 20 m and length of 66 m). Warehouse III has heavy duty racks with a total capacity of 1,311 pallet positions. The layout changes were simulated and the results were obtained, which were changes in travel distance, travel time and total put away and picking process time in each scenario as listed in Table 5.

| Description                  | Scenario I                  | Scenario II                  |
|------------------------------|-----------------------------|------------------------------|
| Put Away Travel Distance (m/month) | 323,273.92 (-5.6%)          | 318,759.23 (-6.9%)          |
| Put Away Travel Time (hour/month)   | 44.90 (-79.1%)              | 44.28 (-79.4%)              |
| Total Put Away Process (hour/month) | 120.59 (68.7%)              | 119.98 (-68.9%)             |
| Picking Travel Distance (m/month)   | 63,458.28 (-1.7%)           | 64,015.34 (-0.9%)           |
| Picking Travel Time (hour/month)    | 8.83 (-86.9%)               | 8.91 (-86.8%)               |
| Total Picking Time (hour/month)     | 432.94 (-65.9%)             | 433.02 (-65.9%)             |

3.4. Cost Analysis
Existing operational cost was obtained from the total of salaries and overtime wages in the process of put away and picking per month. The existing put away process used 2 porters with wages calculated based on the number of raw material unloaded. The put away process must be completed on the 1st shift (8 hours). The amount of raw material that was unloaded at that time was 16 tons. The existing put away cost was 13,478,320 IDR/month. The existing picking process was carried out by 1 warehouse foreman and 6 warehouse workers. Workers' salaries were calculated based on the regional salary of 3,861,518 IDR/month.person with a normal working time of 176 hours/month.person and overtime 1 hour/day.person. The overtime cost in the first 1 overtime hours was calculated as 1x
salary/hour and the next hour was calculated as 2x salary/hour. The existing picking cost was 27,030,626 IDR/month. Thus, the total existing operational cost was 40,508,946 IDR/month.

In the improvement plan, the handling method that originally used the porter was changed to using a forklift. The forklift requirement for warehouse operation was 3 units of forklift and calculated from the total time put away or picking per month divided by the normal working time per month (44 hours/month). The number of workers was 3 persons which was equal to the number of forklift. The forklift requirements were fulfilled with 1 unit of company’s forklift and 2 units of rental forklift. The company's forklift has passed its depreciation period and has zero salvage value. Thus, the operational costs of the improvement plan can be obtained from the total maintenance costs of 1 unit of company’s forklift, rental cost 2 units forklift and the workers’ salary. The total operational cost was 30,772,704 IDR/month. By implementing this improvement, the company could save their operational cost by the estimation of 24.03%.

3.5. Discussion
The warehouse layout changes gave a decrease in put away travel distance of 5.6% for scenario I and 6.9% for scenario II. While the decrease in travel distance that occurs in the picking process was 1.7% for scenario I and 0.9% for scenario II. The handling method change in the put away process gave a decrease in travel time by 79.1% for scenario I and 79.4% for scenario II, and the total time put away is 68.7% for scenario I and 68.9% for scenario II. While in the put away process, the travel time decreased by 86.9% for scenario I and 86.8% for scenario II, and the total picking time is 65.9% for scenario I and scenario II. Based on these results, it can be seen that handling method change gave a better result on the decrease of put away and picking time than the layout change.

The cost analysis was also calculated by comparing the existing operational costs and the improved operational cost. The existing cost was 40,508,946 IDR/month and obtained from the total of salaries and overtime wages in the process of put away and picking per month. In the improvement plan, the method of transfer that originally used the porter was changed to using a forklift. The operational costs of the improvement plan can be obtained from the total maintenance costs of 1 unit of company’s forklift, rental cost 2 units forklift and the workers’ salary. The total operational cost was 30,772,704 IDR/month. The cost saving estimation was 24.03%.

4. Conclusion
This research was conducted at a plastic packaging manufacturer with purpose to reduce the put away and picking time in the raw material warehouse by changing the layout and handling method. Layout change was designed based on raw material selectivity and consumption rate. We proposed and compared two improvement scenarios. Scenario I was designed by ignoring the area for the PET group, while scenario II was designed by determining the area for the PET group. The handling method which was originally using porters was changed to using a forklift. In the put away process, the layout change by determining the PET group area could decrease the travel distance of 6.96%, and the handling method change could decrease the travel time of 79.34% and total put away time of 68.84%. In the picking process, layout change by ignoring the PET group area could decrease in travel distance of 1.81%, and handling method change could decrease in travel time by 86.92% and total picking time of 65.86%. Based on these results, the handling method change could give better result on the decrease of put away and picking time than the layout change. The handling method change gave better result than the layout change on the put away and picking time. By implementing this recommendation, the company could save their operational cost by the estimation of 24.03%.

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