

Warehouse layout Design in Manufacturing Industry

Tranggono^{1,a*}, Nur Rahmawati¹, Kinanti Resmi Hayati¹

¹Department of Industrial Engineering, Faculty of Engineering, UPN "Veteran" Jawa Timur
Rungkut Madya Street No.1, Gn. Anyar, Kec. Gn. Anyar, Surabaya, Indonesia

Corresponding author: ^{a}tranggono.ti@upnjatim.ac.id

Received: 7th April 2021; Revised: 23rd April 2021; Accepted: 27th April 2021;

Available online: 25th May 2021; Published regularly: May and November

Abstract

Manufacturing companies spend a significant amount of time and money designing or redesigning their facilities. It is an extremely important function that must be addressed before products are produced. Manufacturing company's common problem is that they do not have a pattern for placing goods in their warehouse. It leads to problems such as difficulties when taking the product from storage. With storage procedures like this, it can make long total distance for loading and unloading the goods. Dedicated storage policy where storage is done at a certain location according to the type of item needs to be made. The advantage of this method is ease in finding goods as the location can be tailored to the shape of the goods. The research results show an efficiency of the displacement distance of 4117 m, the initial layout distance of moving goods is 5740 m, while in the proposed layout it is 1622 m.

Keywords: Warehouse, Redesigning, Dedicated storage, Layout distance

1. Introduction

Warehouse is a place used to store goods in the form of raw materials, work-in-process, or finished goods [1]. Besides auxiliary materials or supplies, spare parts are also kept in warehouse [2]. There are several activities in warehouse such as receiving, storage, picking, replenishment, retrieval and shipping [3]. In the past, warehouse was just a place to store excess product but now it represents dynamic systems dominant in the movement of goods [4]. Because of its function to store products, sometimes warehouse is called as storage [5].

There are several strategies of storage such as dedicated, random, and class-based [6]. Random storage is allocation of the product in the storage based on available space at time [7]. Dedicated storage is allocation of storage positions based on product type [8]. Meanwhile, class-based storage is arrangement of products in the storage based on certain classes. Each class consists of several products and occupies a fixed position in the warehouse. But, the location of each product in the same class is stored randomly [9]. Class-based

is a combination of randomized and dedicated storage [10].

In Indonesia, there are three sectors that contribute the growth of Gross National Product (GNP) [11], namely manufacture, agricultural, and services. The contribution of manufacturing industries reaches 21.02% in 2014 [12].

This research is conducted in one of manufacturing companies in Indonesia. The problem faced by company is that it doesn't have a storage pattern so that the placement of goods is done randomly. This storage method is inefficient because the operator who takes the goods will need a relatively long time to search them, especially if the operator who is in charge of picking up and storing the goods is a different person. Besides creating difficulties in retrieving goods, this method of storage can also result in a long total distance needed to store and retrieve items.

This research is conducted to solve the problems by applying dedicated storage method. The advantage of dedicated storage is the efficiency of data handling because the data collection is fixed from the items that will go into

The amount of capacity per slot for each item is different, with product's Length (L), Weight (W) and Height (P) can be seen in Table 1:

Table 1. Total Goods Capacity per slot

Product	L	W	H	Slot
Woven bag	5.6	2.8	2	1000
Star pack	5.6	2.8	2	1000
Charging type	5.6	4.4	2	700
JB 2 Loops lifting	5.6	4.4	2	700
JB 4 Loops lifting	5.6	4.4	2	700

Woven Bag has a storage amount per slot of 1000 sheets, and upon receipt for 1 (one) month of 2000 pieces. Then the Space Requirements for woven bag items are:

$$\begin{aligned}
 SR &= 2000/1000 \\
 &= 2 \text{ Slot}
 \end{aligned}$$

Data on incoming and outgoing goods for an average of 1 (one) month for Star Pack goods is 1725 pieces and 1017 sheets. Meanwhile, the receipt of Star Pack goods using a forklift is 100 pieces / pallet. Then the amount of throughput for Star Pack items is:

$$\begin{aligned}
 T &= (1725/1000) + (1017/1000) \\
 &= 27 \text{ Activities}
 \end{aligned}$$

After calculating the wooden bag space requirement and throughput, the next step is to calculate the ratio of throughput to space requirement (T/SR). As shown in Table 2.

Table 2. Ratio between throughput to space requirement

Product	SR	T	T/SR
Woven bag	2	38	19
Star pack	2	27	13.5
Charging type	2	21	10.5
JB 2 Loops lifting	2	12	6
JB 4 Loops lifting	2	16	8

3.1. Initial Travel Distance Product

Calculation of the distance traveled JB charging product for each slot to the i point, where the distance traveled is the distance that the item must travel to the existing slot, with the i point as

the starting point of its journey. The distance is measured along the path of one another with Xi value is 0 and D as distance (meter). As shown in Table 3.

Table 3. Initial Travel Distance JB charging product

Product	Xj	Yi	Yj	D
JB charging type 1	6.5	9	4.3	1.8
JB charging type 2	31.5	9	14.7	37.3
JB charging type 3	45.4	9	14.7	51.1
JB charging type 4	43.2	9	3	37.5

Calculation of the distance traveled JB loops lifting product for each slot to the i point, the distance is measured along the path of one another with Xi value is 0 and D as distance (meter). As shown in Table 4.

Table 4. Initial Travel distance JB loops lifting product

Product	Xj	Yi	Yj	D
JB 2 loops lifting 1	18.8	9	4.3	14.1
JB 2 loops lifting 2	36.4	9	14.7	42.1
JB 2 loops lifting 3	33.1	9	14.7	38.8
JB 4 loops lifting 1	23.6	9	4.3	18.9
JB 4 loops lifting 2	14.3	9	4.3	9.6
JB 4 loops lifting 3	25.3	9	3.3	19.6
JB 4 loops lifting 4	38.5	9	14.7	44.2

Calculation of the distance traveled Woven bags and Star pack product for each slot to the i point, the distance is measured along the path of one another with Xi value is 0 and D as distance (meter). As shown in Table 5.

Table 5. Initial Travel distance woven bag and star pack

Product	Xj	Yi	Yj	D
Woven Bag 1	10.5	9	4.3	5.8
Woven Bag 2	21.4	9	4.3	16.7
Woven Bag 3	43.6	9	14.7	49.3
Star Pack 1	18.3	9	4.3	13.6
Star Pack 2	29.2	9	4.3	34.9
Star Pack 3	27.6	9	14.7	33.3
Star Pack 4	40.4	9	14.7	46.1

3.2. Placement Distance Product Per Slot

In the initial condition, placement is carried out in any empty place, so that goods are free to be placed anywhere. This condition leads to huge displacement distance. For the calculation with D as distance (meter), and P as distance placement (meter). For JB product as placement distance calculation, shown in Table 6.

Table 6. Initial Placement Distance JB charging product

Product	D	T/SR	P	Slot
JB charging type 1	1.8	10.5	18.9	1
JB charging type 2	37.3	10.5	391.	2
JB charging type 3	51.1	10.5	535.	3
JB charging type 4	37.5	10.5	393.	4

For the calculation with D as distance (meter), and P as distance placement (meter). For JB loops lifting product as placement distance calculation, shown in Table 7.

Table 7. Initial Placement Distance JB loops lifting product

Product	D	T/SR	P	Slot
JB 2 loops lifting 1	14.1	6	84.6	5
JB 2 loops lifting 2	42.1	6	252.	6
JB 2 loops lifting 3	38.8	6	232.	7
JB 4 loops lifting 1	18.9	8	151.	8
JB 4 loops lifting 2	9.6	8	76.	9
JB 4 loops lifting 3	19.6	8	156.	10
JB 4 loops lifting 4	44.2	8	353.	11

For the calculation with D as distance (meter), and P as distance placement (meter). For Woven bags and Star pack product as placement distance calculation, shown in Table 8.

Table 8. Initial Placement Distance Woven bags and Star pack product

Product	D	T/SR	P	Slot
Woven Bag 1	5.8	19	110.	12
Woven Bag 2	16.7	19	317.	13
Woven Bag 3	49.3	19	936.	14
Star Pack 1	13.6	13.5	183.	15
Star Pack 2	34.9	13.5	471.	16
Star Pack 3	33.3	13.5	449.	17
Star Pack 4	46.1	13.5	622.	18

From the placement of the goods above, it can be seen that the total travel distance in the initial condition layout is 5,740.1 m.

3.3. Proposal Improvement

To find out the total distance in the proposed layout, the throughput ranking must be done with the Space Requirement, then ranking the finished goods for the proposed layout, then the calculation of the travel distance for each slot. From the placement of the goods above, it can be seen that the total trip distance in the proposed layout (JU) is 2,089.65 m. The result can be seen in Table 9.

Table 9. Ranking for placement distance for all product

Product	D	T/SR	P	Slot
Star Pack 1	12.2	13.5	27	1
Star Pack 2	20.1	13.5	64.8	2
JB charging type 1	10.6	10.5	128.	3
JB charging type 2	15.5	10.5	211.	4
Woven Bag 1	22.6	19	201.	5
Woven Bag 2	30.5	19	294.	6
JB 4 loops lifting 1	38.4	8	180.	7
JB 4 loops lifting 2	46.3	8	244	8
JB 2 loops lifting 1	12.2	9	345.	9
JB 2 loops lifting 2	20.1	9	416.	10

Based on slot ranking for placement distance for all product, the proposed layout placement is as follows:

- [5] Silva, A., Coelho, L. C., Darvish, M., & Renaud, J., "Integrating storage location and order picking problems in warehouse planning", *Transportation Research Part E: Logistics and Transportation Review*, no. 140, pp. 102003, 2020.
- [6] Žulj, I., Glock, C. H., Grosse, E. H., & Schneider, M., "Picker routing and storage-assignment strategies for precedence-constrained order picking", *Computers & Industrial Engineering*, no. 123, pp. 338-347, 2018.
- [7] Muharni, Y., & Khoirunnisa, M., "Warehouse layout designing of slab using dedicated storage and particle swarm optimization". In *IOP Conference Series: Materials Science and Engineering*, , vol. 532, no. 1, pp. 012003, May, 2019.
- [8] Alfathi, N., Lyhyaoui, A., & Sedqui, A., "Fusion of dedicated and shared storage to maximize the use of space of static warehouses". *Journal of Industrial and Production Engineering*, vol. 36, no. 8, pp. 512-532, 2019.
- [9] Tostani, H. H., Haleh, H., Molana, S. H., & Sobhani, F. M., "A Bi-Level Bi-Objective optimization model for the integrated storage classes and dual shuttle cranes scheduling in AS/RS with energy consumption, workload balance and time windows", *Journal of Cleaner Production*, no. 257, pp.120409, 2020.
- [10] Klodawski, M., Jachimowski, R., Jacyna-Golda, I., & Izdebski, M., "Simulation analysis of order picking efficiency with congestion situations", *International Journal of Simulation Modelling*, vol. 17, no. 3, pp.431-443, 2018.
- [11] Susilastuti, D., "Agricultural production and its implications on economic growth and poverty reduction", 2018, Athens, Greece: University of Piraeus.
- [12] Masdupi, E., Tasman, A., & Davista, A., "The influence of liquidity, leverage and profitability on financial distress of listed manufacturing companies in Indonesia", In *First Padang International Conference On Economics Education, Economics, Business and Management, Accounting and Entrepreneurship (PICEEBA)*, Jul., 2018, pp. 389-394.
- [13] Dianto, C., Widiandoko, F., Rahmanasari, D., & Sutopo, W., "Redesign Production Layout Using Dedicated Storage Method: Case Study of PT. Solo Grafika Utama", In *IOP Conference Series: Materials Science and Engineering*, Oct., 2020, vol. 943, no. 1, pp. 012042.
- [14] Ramadhan, R. I., Krenius, M., Rifni, M., Nunuh, N., & Ferdiansyah, A., "Improvement of Layout of Product Placement, Placement Using Dedicated Storage Method in PT. Cipta Krida Bahari", *Advances in Transportation and Logistics Research*, no. 2, pp. 85-91, 2019.
- [15] Zhang, R. Q., Wang, M., & Pan, X., "New model of the storage location assignment problem considering demand correlation pattern", *Computers & Industrial Engineering*, no. 129, pp. 210-219, 2019.
- [16] Wang, M., Zhang, R. Q., & Fan, K., "Improving order-picking operation through efficient storage location assignment: A new approach", *Computers & Industrial Engineering*, no. 139, pp. 106186, 2020.
- [17] Chabot, T., Lahyani, R., Coelho, L. C., & Renaud, J., "Alternative heuristics for solving the multi-constrained order picking problem", In *2017 9th IEEE-GCC Conference and Exhibition (GCCCE)*, May, 2017, pp. 1-5.
- [18] Fontana, M. E., Nepomuceno, V. S., & Garcez, T. V., "A hybrid approach development to solving the storage location assignment problem in a picker-to-parts system", *Brazilian Journal of Operations & Production Management*, vol. 17, no. 1, pp. 1-14, 2020.
- [19] Septiani, W., Divia, G. A., & Adisuwiryono, S., "Warehouse Layout Designing of Cable Manufacturing Company using Dedicated Storage and Simulation Promodel", In *IOP Conference Series: Materials Science and Engineering*, vol. 847, no. 1, pp. 012054, April, 2020.
- [20] Zapata-Cortes, J. A., Arango-Serna, M. D., Serna-Urán, C. A., & Adarme-Jaimes, W., "Mathematical model for product allocation in warehouses", In *Techniques, Tools and Methodologies Applied to Global Supply Chain Ecosystems*, pp. 191-207, 2020.
- [21] Heragu, S., "Facility Design", 3rd Edition, CRC Press Publisher, New York, 2008.