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Article

Warehouse layout Design in Manufacturing Industry

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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 storage [13]. There are many researches that have been done before such as [13] and [14]. Apart from these two, there are several others with the same method but combined with the heuristic method such as [15], [16], and [17].

2. Material and Method

Dedicated storage is a fixed storage policy where goods are stored in a specific location [18] according to the type of item [19]. This policy is designed by specifying the location in the product codification [20].

The problem of placing dedicated storage can be formulated as a transportation problem. When the percentage of trips between the i point and the storage / withdrawal location is the same for all goods, the following procedure can be used to produce optimum solution to the dedicated storage placement problem. Amount of goods according to their throughput ratio (Tj) and storage requirements (Sj).

$$T_1/S_1 \geq T_2/S_2 \geq \cdots T_n/S_n \mid \quad (1)$$

The purpose of the ranking procedure is to place the item with the largest ratio of Th to Fj in the slots with the lowest average travel distance (DK value), place the item with the next largest ratio to the next lowest travel distance, and so on. As previously emphasized, the procedure is based on the critical assumption that all items stored have the same percentage distribution of movement between storage or withdrawal locations and i points.

$$DK = | xi - xj | + | yi – yj | \quad (2)$$

Space requirement (SR) is the number of places or areas occupied by one type of goods. Space requirements are needed to determine the storage capacity in the available slot or storage area, so that it will be known how many slots are needed to store one type of item. Then, it can be calculated whether the number of available slots in the warehouse is sufficient or not. With space requirement (SR), Receipt average (R) and Storage amount /slot (C), The formula used is:

$$SR = R/C \quad (3)$$

The calculation of throughput is based on the activity of the recipient / delivery at the warehouse for finished goods on average per month. With Throughput (T), Incoming goods average/ day (I), Outcoming goods average (O), and Total good receipt (Gtot), the formula used is:

$$T = (I/Gtot) + (O/Gtot) \quad (4)$$

3. Results and Discussion

The total warehouse area is 864 m (48 m x 18 m). The arrangement of goods in the warehouse is currently irregular because there is no specific place for storing one type of item. Incoming goods will be stored in an empty storage area. The following image is the current finished goods warehouse layout:

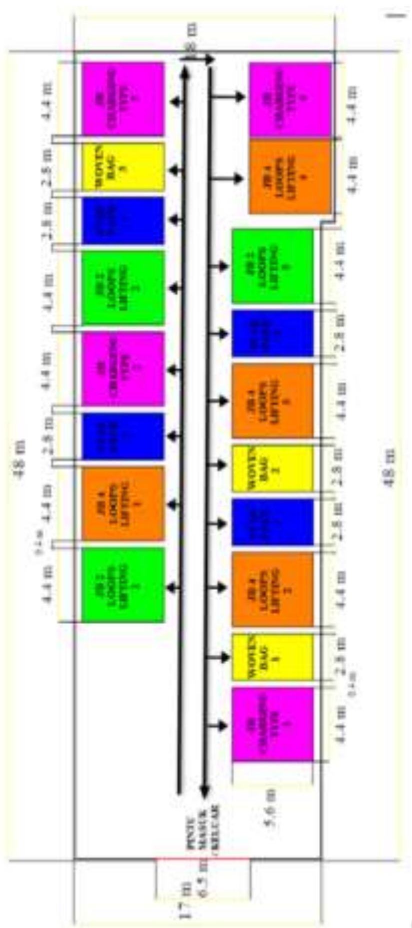

Fig. 1. Warehouse initial layout

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:

$$SR = 2000/1000 = 2 \text{ Slot}$$

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:

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

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:

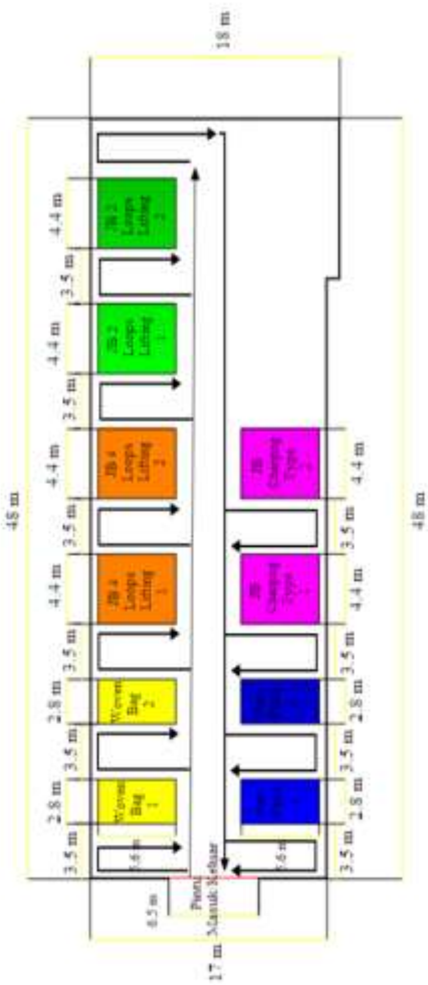

Fig. 2. Warehouse Proposal Layout

3.4. Discussion

Some methods proposed in warehouse re-layout cases are very diverse. The use of method is not weaker nor superior but rather more effective or efficient. It is like the randomized storage method which is able to overcome the low space utilization in dedicated storage method because the space provided for each product cannot be used for other products provision. However, the randomized storage method has a drawback if the number of products allocated has various types, then the time to search for and pick up products will be long [21]. Shared storage location method is able to overcome the weakness of the two methods above by recognizing and utilizing the length of storage time on certain pallets that are fixed in the warehouse. In order to apply this method, we have to know when the product will come in and come out. so that, the product location can be adjusted according to its place.

4. Conclusions

Based on the calculations, the initial condition of the trip distance for moving goods is 5,740.1 m and the proposed condition for implementing dedicated storage is 2,089.65 m. So, it is known that there has been a decrease in the total travel distance by a difference of 3,650.45 m. So that the placement of the proposal is more effective because there is a reduction in the travel distance for the transfer of materials from the initial condition and the condition of the proposed application of dedicated storage.

So that the placement of the proposal is more effective because there is a reduction in the travel distance for the transfer of materials from the initial condition and the condition of the proposed application of dedicated storage.

For future research, the author is not only be able to use several re-layout methods to find problem solutions but also find the best alternative solution among the use of these methods.

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