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Layout Analysis of Goods Storage: Case Study Spare Part Warehouse Z Company

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Abstract

This research is a case study to solve the problems that occur at PT. Z, which is engaged in palm oil processing. The case raised is the spare parts warehouse of PT. Z, where the problem that has occurred so far is the policy of random storage in the spare parts warehouse. This results in irregularities that complicate the process of receiving, storing, searching and releasing spare parts, which is indicated by the high total travel distance in the warehouse. Thus, the purpose of this study is to minimize the total travel distance in the spare parts warehouse by using a dedicated storage policy which is based on an analysis of the product storage layout (spare parts). Based on the results of data processing using a dedicated storage policy, the initial trip distance is 4257,25 meters and the proposed trip distance is 4002,5 meters. From these conditions, it can be concluded that using a dedicated storage policy can reduce the total travel distance in the spare parts warehouse by 254,75 meters or around 5,98%.

Keywords: *layout analysis, warehouse, dedicated storage policy, product storage layout, total travel distance*

Introduction

The problem faced by Z company which is engaged in processing palm oil (CPO) is the inflow of goods in the form of spare parts to be stored is not well coordinated and the storage space is not wide enough. Therefore some goods are placed on the warehouse floor due to limited storage space. This will result in road obstructions and makes it difficult to pick up goods. And also can make it difficult to organize the storage of goods and the process of finding goods which takes time. In the end, the goods are arranged irregularly and the arrangement of the warehouse is always changed in order to provide storage room. Good warehouse management will be able to save 30% of logistics costs in Europe and in the US (Fumi, Scarabotti, & Schiraldi, 2013; Sitorus, Rudianto, & Ginting, 2020). Good warehouse management can be done by redesigning the warehouse layout (Fumi et al., 2013). Warehouse layout concerns storage space and material handling arrangements aimed at maximizing space utility, efficiency, lowering costs, and increasing productivity by minimizing the mileage to store (storage) and take (order picking) an item. This will be influenced by the dimensions of the warehouse, the length of the aisle (pick aisle and cross aisle), picking methods, material handling systems, and supporting information technology infrastructure (Abdullah, 2009; Meldra & Purba, 2018; Patrisina, 2010; Sitorus et al., 2020).

There are five storage policies that can be used to organize products that come into the warehouse, one of which is a dedicated storage policy (Heragu, 2016). Each policy has its own advantages and disadvantages, random storage policy is useful for minimizing storage space, dedicated storage policy is useful for minimizing costs and the number of material handling trips. Class-based storage policies are useful for minimizing storage space and the cost and number of material handling trips (Heragu, 2016). While the

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shared storage policy is rarely used to solve warehouse layout problems in the industrial world.

In the case of company Z is resolved using a dedicated storage policy. Dedicated storage policy is used to evaluate the layout of product warehouse storage that varies in type and quantity (Fumi et al., 2013; Hermanto, 2020; Kelvin, Pram Eliyah Yuliana, & Sri Rahayu, 2020; Meldra & Purba, 2018; Sitorus et al., 2020). The policy is also used to evaluate the layout of the warehouse for one type of product (Harjono & Prasetyawan, 2010; Patrisina, 2010; Permana, 2014). In addition, a dedicated storage policy was implemented to increase the allocation of storage space and minimize the number of trips for material handling equipment (Abdullah, 2009; Fumi et al., 2013; Hermanto, 2020; Kelvin et al., 2020; Meldra & Purba, 2018; Patrisina, 2010; Permana, 2014; Sitorus et al., 2020). In this study, the implementation of a dedicated storage policy is used to evaluate warehouses that store products with varying amounts and types by taking into account the allocation of storage space and the number of trips for material handling equipment. However, the difference between this article and the reference article is that the storage space uses standard spare parts storage racks.

Literature Review

Material handling activities account 30-75% of production operational costs in the manufacturing system are used for (Heragu, 2016; Sule, 2008). Inter-departmental arrangement in the manufacturing system is able to reduce the cost of material handling. Therefore, departmental arrangement or storage area arrangement in a facility can reduce material handling costs and reduce the number of trips for material handling equipment (Fumi et al., 2013; Heragu, 2016; Sule, 2008).

Warehouse

Warehouse is a facility/building that has the main function as a temporary storage place for raw materials/semi-finished goods/finished products/spare parts (Abdullah, 2009; Heragu, 2016; Kelvin et al., 2020; Meldra & Purba, 2018; Permana, 2014). Based on the understanding of the warehouse, the general purpose of storing products in the warehouse is for supervision, selection, and stockpiling. Based on the type of material stored, the warehouse can be divided into raw material warehouses, work-in-process warehouses, finished goods warehouses, warehouses for supply goods, rework material warehouses, and damaged material warehouses (Abdullah, 2009; Permana, 2014).

Dedicated Storage Policy

Dedicated storage policy refers to a policy in storing items/materials in a place/location that has been determined with certain rules. Based on these rules, the dedicated storage policy can be divided into part-number sequence storage and throughput-based dedicated storage. Part-number sequence storage is a rule for placing materials/items at a fixed location based on the part numbering assigned to the item/material. the lower the value indicated by the part numbering, the closer the item/material is to the I/O point. In this rule, the part numbering does not take into account the rate of demand, the frequency of material/item/handling equipment travel, and is assigned randomly.Therefore, if the part number assigned to the item/goods is low, demand is low, the frequency of travel for items/goods/handling equipment is low, it will cause low warehouse utility. (Abdullah, 2009; Heragu, 2016; Permana, 2014)

Throughput-based dedicated storage is a solution for the shortcomings that occur in this type of dedicated part numbering. Storage rules in this type are based on storage activities and storage requirements of items/materials. Therefore, part numbering is determined based on the storage activity and storage requirements of each item/material. Thus, items/materials that have a high demand rate and high travel frequency of items/materials/equipment handling will be placed close to the I/O point. throughput type dedicated storage is the most frequently used so it is referred to as dedicated storage itself.

As for the rules used to place items/products in the storage area for dedicated storage, they are sorted based on the comparison value of throughput and storage space requirements and the total value of the journey taken by the item/material/equipment handling from each storage area to the I/O point. Based on this

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explanation, it is necessary to first calculate the throughput value and storage space requirements for each item/material as well as the total journey of each storage area to the I/O point. The following is the formula used to determine the required storage space, throughput, and total trips to the I/O point (Abdullah, 2009; Kelvin et al., 2020; Meldra & Purba, 2018; Permana, 2014).

Equation 1 is used to calculate the space requirement.

$$S_j = \frac{average\ item\ received}{block\ capacity} \quad \text{Eq. 1}$$

S_j : storage space requirements per item j
j = 1, 2, 3,.., m

Equation 2 is used to calculate the throughput.

$$T_j = \frac{average\ item\ received}{one-way\ capacity} + \frac{average\ item\ shipped}{one-way\ capacity} \quad \text{Eq. 2}$$

T_j : throughput per item j
j = 1, 2, 3,.., m

Equation 3 is used to calculate the distance measurement used in this study is using the reclinear distance method.

$$d_{ij} = |x_i - x_j| + |y_i - y_j| \quad \text{Eq. 3}$$

d : distance from space area j to I/O point i
i = 0
j = 1 in existing layout
2 in proposed layout

Equation 4 is used to calculate the total trips.

$$TT = S_j * \frac{Tj}{Sj} * \frac{dij}{Sj} \quad \text{Eq. 4}$$

TT : total trips
S : space requirement per item
T : throughput per item
j = 1, 2, 3,.., m
i = 0

Methodology

The research was conducted at the spare parts warehouse of company Z, the research phase will begin when conducting a survey at the spare parts warehouse of company Z. The research carried out can run well and smoothly, it is necessary to carry out stages that flow from beginning to end. Figure 1 provides an overview of the research stages and the methodology used.

In addition, there are some data needed for research needs. The data includes the average item data received, the average item data sent, item/material type data, storage area data, initial warehouse layout, and other required data. The data is processed to obtain a layout arrangement for the proposed storage of items/materials in the warehouse based on the total trip. Items/materials stored in the warehouse are spare parts for production purposes. From Table 1 it is known that there are 24 types of spare parts stored in the warehouse. From the table it is also known that the average item received every three months is much higher than the average item sent.

Figure 2 provides an overview of the initial position of each type of spare part item in the warehouse. From the layout it can be seen that there are eight shelves. provided that one shelf is a shelf consisting of three columns and two levels.

Table 1. Average item received and average item shipped for three months

No	Item	In	Out
1	(MBR-1)	400	92
2	(SC-2)	350	71
3	(ES-3)	300	32
4	(BG-4)	85	27
5	(SG-5)	65	21
6	(PBS-6)	80	19
7	(SM-7)	40	17
8	(BSKF-8)	55	12
9	(ABD-9)	50	9
10	(KL-10)	25	9
11	(SSBV-11)	60	7
12	(BSKF-12)	25	6
13	(ESP-13)	35	6
14	(EP-14)	30	6
15	(FSE-15)	50	6
16	(BO-16)	20	6
17	(BSKF-17)	25	4
18	(KL-18)	10	4
19	(BDP-19)	40	3
20	(BSKF-20)	25	2
21	(HBB-21)	30	2
22	(BCS-22)	30	2
23	(HBS-23)	20	1
24	(EPV-24)	30	1

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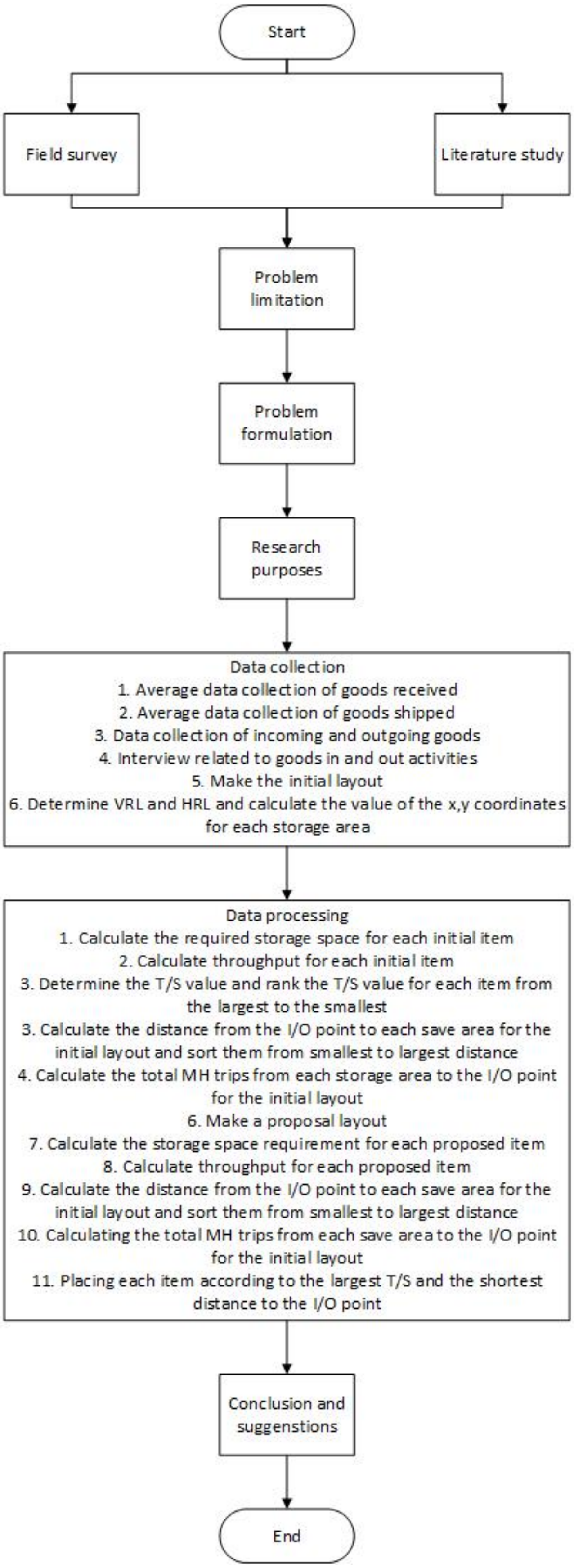

Figure 1. Research Methodology

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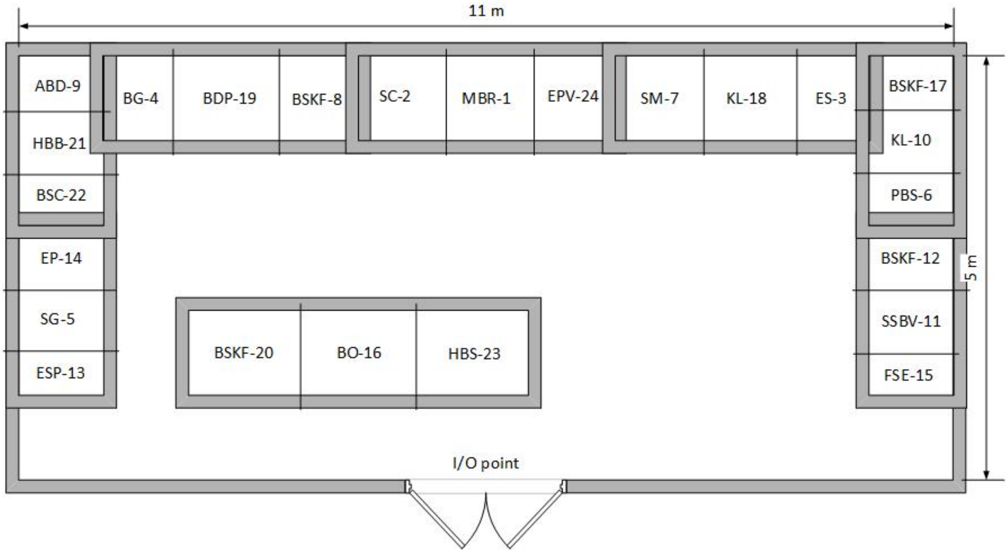

Figure 2. Initial placement of each spare parts warehouse item

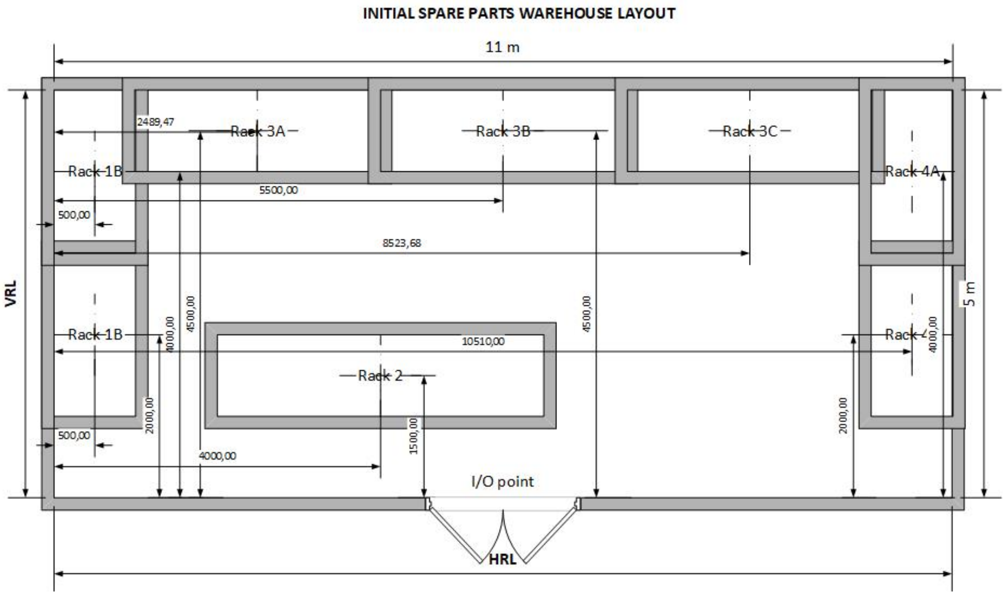

Figure 3. Initial spare parts warehouse layout

While in Figure 3 the dimensions of the spare parts warehouse and the coordinate values (x,y) are known for each shelf. The information contained in Figure 3 is used to obtain the value of the distance between each shelf and the I/O point shown in Table 2.

Results

Based on the equation described previously, data processing begins by first determining the value of the initial storage space requirement for each item/material using Equation 1. After that, it is continued by calculating the initial throughput for each item/material using Equation 2. after that, the initial distance of each area save to the I/O point is calculated using Equation 3 and ends by calculating the total trips from each storage area to the I/O point. The final stage is to calculate the total initial trip for each item to the I/O point using Equation 4.

Table 3 contains information on the initial calculating the storage space requirements for each spare part item. by using the formula Equation 1, it can be found that theoretically the space requirement has a decimal value below one. Therefore, for practical purposes, the space requirement is rounded up to 1. The following is the calculation of one of the spare parts items to obtain the storage space requirement.

$S_{MBR-1} \approx \frac{400}{400*2}$ = 0,5 (theoretical) ≈ 1 block (practical)

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Table 2. Summary of coordinate value of x,y

No	Item j	X_j	Y_j
1	MBR-1	5,5	0,5
2	SC-2	5,5	0,5
3	ES-3	2,50	0,50
4	BG-4	8,50	0,50
5	SG-5	10,5	3,75
6	PBS-6	0,50	1,25
7	SM-7	2,50	0,50
8	BSKF-8	8,50	0,50
9	ABD-9	10,5	1,25
10	KL-10	0,5	1,25
11	SSBV-11	0,50	3,75
12	BSKF-12	0,50	3,75
13	ESP-13	10,50	3,75
14	EP-14	10,50	3,75
15	FSE-15	0,50	3,75
16	BO-16	7,50	4,50
17	BSKF-17	0,50	1,25
18	KL-18	2,50	0,50
19	BDP-19	8,5	0,5
20	BSKF-20	7,5	4,5
21	HBB-21	10,5	1,25
22	BCS-22	10,5	1,25
23	HBS-23	7,5	4,5
24	EPV-24	5,5	0,5

Table 3 also contains information about the initial calculation of the throughput value for each spare part item. By using the formula in Equation 2 and information on the initial storage space requirements for each item, the initial throughput value is obtained. In addition to information related to space requirements, the throughput value also requires data on one-time transport of items when they are moved, data on average receipts, and average deliveries (sent). The following is an example of calculating the throughput value for MBR-1 items.

$T_{MBR-1} \approx \frac{400}{5} + \frac{92}{5} = 98$

After the information about the storage space requirements and the initial throughput for each item is found, the next step is to calculate the distance between each item of spare parts located on each shelf to the I/O point. Table 4 provides information about the distance between each item on the shelf to the I/O point. The following is a calculation for one of them.

$d_{I/O\ to\ MBR} \approx |0\text{-}5{,}5|+|5{,}5\text{-}0{,}5| = 10{,}5$

Table 3. Summary of initial space requirement, throughput for each item

No	Item	Average received	Capacity	Stack height	Sj theoretical	Sj block	Average shipped	Numbers of transport	T_j	S_j	T/S
1	MBR-1	400	400	2	0,50	1	92	5	98	1	98
2	SC-2	350	350	2	0,50	1	71	5	84	1	84
3	ES-3	300	300	2	0,50	1	32	5	66	1	66
4	BG-4	85	100	2	0,42	1	27	5	22	1	22
5	SG-5	65	70	2	0,46	1	21	5	17	1	17
6	PBS-6	80	100	2	0,40	1	19	5	20	1	20
7	SM-7	40	50	2	0,40	1	17	5	11	1	11
8	BSKF-8	55	60	2	0,45	1	12	5	13	1	13
9	ABD-9	50	50	2	0,50	1	9	5	12	1	12
10	KL-10	25	30	2	0,42	1	9	5	7	1	7
11	SSBV-11	60	60	2	0,500	1	7	5	13	1	13
12	BSKF-12	25	30	2	0,42	1	6	5	6	1	6
13	ESP-13	35	50	2	0,35	1	6	5	8	1	8
14	EP-14	30	30	2	0,50	1	6	5	7	1	7
15	FSE-15	50	50	2	0,50	1	6	5	11	1	11
16	BO-16	20	20	2	0,50	1	6	5	5	1	5
17	BSKF-17	25	30	2	0,42	1	4	5	6	1	6
18	KL-18	10	20	2	0,25	1	4	5	3	1	3
19	BDP-19	40	50	2	0,40	1	3	5	9	1	9
20	BSKF-20	25	30	2	0,42	1	2	5	5	1	5
21	HBB-21	30	30	2	0,50	1	2	5	6	1	6
22	BCS-22	30	30	2	0,50	1	2	5	6	1	6
23	HBS-23	20	30	2	0,33	1	1	5	4	1	4
24	EPV-24	30	30	2	0,50	1	1	5	6	1	6

Table 4. The initial distance from the I/O point and distance travelled to each initial storage area

No	Item	X (I/O)	Y (I/O)	X1	Y1	Distance	Travel distance/Block
1	MBR-1	0	5,50	5,50	0,50	10,50	1029
2	SC-2	0	5,50	5,50	0,50	10,50	882
3	ES-3	0	5,50	2,50	0,50	7,50	495
4	BG-4	0	5,50	8,50	0,50	13,50	297
5	SG-5	0	5,50	10,50	3,75	12,25	208,25
6	PBS-6	0	5,50	0,50	1,25	4,75	95
7	SM-7	0	5,50	2,50	0,50	7,50	82,50
8	BSKF-8	0	5,50	8,50	0,50	13,50	175,50
9	ABD-9	0	5,50	10,50	1,25	14,75	177
10	KL-10	0	5,50	0,50	1,25	4,75	33,25
11	SSBV-11	0	5,50	0,50	3,75	2,25	29,25
12	BSKF-12	0	5,50	0,50	3,75	2,25	13,50
13	ESP-13	0	5,50	10,50	3,75	12,25	98
14	EP-14	0	5,50	10,50	3,75	12,25	85,75
15	FSE-15	0	5,50	0,50	3,75	2,25	24,75
16	BO-16	0	5,50	7,50	4,50	8,50	42,50
17	BSKF-17	0	5,50	0,50	1,25	4,75	28,50
18	KL-18	0	5,50	2,50	0,50	7,50	22,50
19	BDP-19)	0	5,50	8,50	0,50	13,50	121,50
20	BSKF-20	0	5,50	7,50	4,50	8,50	42,50
21	HBB-21	0	5,50	10,50	1,25	14,75	88,50
22	BCS-22	0	5,50	10,50	1,25	14,75	88,50
23	HBS-23	0	5,50	7,50	4,50	8,50	34
24	EPV-24	0	5,50	5,50	0,50	10,50	63
Total trips for initial layout							4257,25

The final step in this initial stage is to calculate the total trips from each shelf item to the I/O point. Table 4 also provides the required data and the total results of the trip. The following is an example of calculating the total trip of one of the shelf items to the I/O point.

$TT_{MBR\text{-}1} \approx 1*98*\frac{10,5}{1} = 1029$

Discussion

After the initial stages are carried out, the next stage is to determine a proposal for evaluating the layout of the spare parts item storage. As for the initial proposal by making a proposed layout based on the T/S ranking that has been done in Table 3. After the proposed layout is made, then the next step is to recalculate the proposed distance for each shelf item that has changed its arrangement to the I/O point.Before the distance is determined, the coordinate value (x,y) is searched for each shelf item to the I/O point. Table 5 below is the coordinates (x,y) of the proposal that has undergone a change in position. While the change in the position of the proposed layout can be seen in Figure 4.

By obtaining the coordinate values (x,y) for each spare parts item storage area, the next step is to calculate the distance between the I/O points to each spare parts item storage area. It's also gives the overall distance of each spare parts item storage area to the I/O point. The following is an example of calculating the distance between a spare parts item store area to an I/O point.

$d_{I/OtoMBR\text{-}1} \approx |0-7,5|+|5,5-4,5| = 8,5$

After the distance between each storage area for spare parts items to the I/O point is known, the next step is to calculate the total distance traveled by all spare parts items. Table 5 also provides an overall picture of the total trip value. The following is an example of calculating the total trip for one of the spare parts item storage areas.

$TT_{I/OtoMBR\text{-}1} \approx 1*98*\frac{8,5}{1} = 833$

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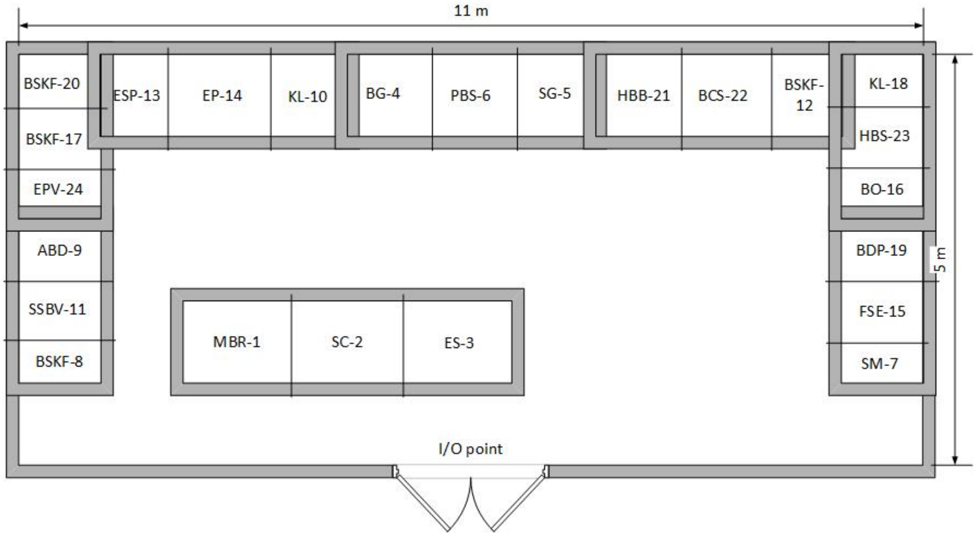

Figure 4. Proposed layout

Table 5. Summary of proposed coordinate (x,y)

No	Item	x_2	y_2	$x_{(I/O)}$	$y_{(I/O)}$	Distance Block to I/O	Total trip/Block
1	MBR-1	7,50	4,50	0	5,50	8,50	833
2	SC-2	7,50	4,50	0	5,50	8,50	714
3	ES-3	7,50	4,50	0	5,50	8,50	561
4	BG-4	5,50	0,50	0	5,50	10,50	231
5	SG-5	5,50	0,50	0	5,50	10,50	178,5
6	PBS-6	5,50	0,50	0	5,50	10,50	210
7	SM-7	0,50	3,75	0	5,50	2,25	24,75
8	BSKF-8	10,50	3,75	0	5,50	12,25	159,25
9	ABD-9	10,50	3,75	0	5,50	12,25	147
10	KL-10	8,50	0,50	0	5,50	13,50	94,5
11	SSBV-11	10,50	3,75	0	5,50	12,25	159,25
12	BSKF-12	2,50	0,50	0	5,50	7,50	45
13	ESP-13	8,50	0,50	0	5,50	13,50	108
14	EP-14	8,50	0,50	0	5,50	13,50	94,5
15	FSE-15	0,50	3,75	0	5,50	2,25	24,75
16	BO-16	0,50	1,25	0	5,50	4,75	23,75
17	BSKF-17	10,50	1,25	0	5,50	14,75	88,5
18	KL-18	0,50	1,25	0	5,50	4,75	14,25
19	BDP-19)	0,50	3,75	0	5,50	2,25	20,25
20	BSKF-20	10,50	1,25	0	5,50	14,75	73,75
21	HBB-21	2,50	0,50	0	5,50	7,50	45
22	BCS-22	2,50	0,50	0	5,50	7,50	45
23	HBS-23	0,50	1,25	0	5,50	4,75	19
24	EPV-24	10,50	1,25	0	5,50	14,75	88,5
Total trips for proposed layout							4002,5

After all the steps are completed, the next step is to compare the initial total trip to the proposed total trip. the initial total trip obtained was 4257,25 and the total proposed trip was 4002,5. Based on this value, it is known that there is a significant change before the product storage layout is repaired and after the repair is done using a dedicated storage policy. the change is a decrease in the total distance traveled by each item of spare parts in the warehouse by 5,98%.

In previous studies, the steps in finding the coordinates for each storage area for each product were not shown. Meanwhile, in this study, the coordinates for each storage area for each product are explained. The coordinate points are searched by first determining the vertical reference line and the horizontal reference line. After that, a straight line is drawn from the midpoint of the storage area for each spare part to a vertical line to find the x-coordinate value. Meanwhile the value of the y-coordinate is obtained by drawing a straight line from the midpoint of each storage area of each spare part to a horizontal line. It is shown in Figure 3.

Conclusion

Description of the layout of the goods in the spare parts warehouse before the arrangement with the Dedicated Storage method at company Z was carried out randomly and not yet arranged. The process of receiving, searching and releasing goods will certainly take quite a while because of the random arrangement of items. According to the initial layout, the total mileage for each block of goods to the I/O Point is 4257,25 m. the proposed layout of spare parts at company Z, resulted in a better arrangement pattern. Where the goods are arranged according to the value of the largest receipt and expenditure activity, and later the goods are placed closest to the I/O Point to reduce the total distance traveled for the movement of the goods. the proposed layout produces a total mileage of 4002,5 m. and finally, the results showed that the comparison of the layout of spare parts at company Z before repair and after repair, succeeded in reducing the total distance of moving goods by 254,75 m or by 5,98%.

It is also advisable to improve the overall condition of the warehouse layout. Not only pay attention to product storage but also pay attention to the overall condition of the warehouse. In a broad sense rearranging the layout of the warehouse by paying attention to all facilities, activities, areas in the warehouse. As is known, the warehouse does not only consist of a product storage area but also an office, reception area, delivery area, toilers, and other supporting facilities.

Limitation of Research

In this study, the evaluation of the warehouse layout only considers the total distance traveled by each item to the I/O point. while in theory it is determined that in evaluating the layout of the facility there are three main aspects, namely cost, frequency of trips, and distance. Therefore, in further research, it can be evaluated using aspects of cost and travel frequency. In addition, this study only considers the distance traveled by the item to the I/O point, while there are other things that need to be considered besides the distance traveled by the item, namely the distance from material handling equipment. it is recommended that further research should consider material handling equipment. In this study is only limited to the analysis of product storage layouts and does not mention the problem of designing a new layout at all. Therefore, in the future, you should consider conducting an analysis of the evaluation and improvement of the overall warehouse layout.

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