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Design of Layout for Chemical Warehouse PT. XYZ with Heuristic Approach and Shared Storage Method to Improve Capacity and Reduce Out of Block Product

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Abstract. PT. XYZ is an enterprise for sales services, maintenance, repair and spareparts provider of Toyota. To support its function, PT XYZ has regional parts depo Bandung, a distribution warehouse that supply spare parts product to the whole region of West Java. PT. XYZ has two types of warehouses, non-chemical and chemical warehouses. chemical warehouse is a warehouse with 86 m2 area that arranged floor storage stack based on the block allocated for the associated SKU. The problems experienced in chemical warehouse at the moment is the number of products that are not absorbed and stored off site storage. Conditions due to a few blocks overcapacity and several kinds of products that do not have a storage block. Steps being taken to resolve the problemconsists of two stages. First, redesign the warehouse layout with heuristic method approach to improve warehouse capacity. Second, redesign warehouse storage allocation by using shared storage method in every alternatives to reduce out of block product. Based on the calculation, best proposed layout is an alternative with horizontal aisle and 4-1 lane depth. The proposed layout proved to increase capacity by 27% to 124 pallet positions and minimize the amount of storage out of the block into 0%.

Keywords: Warehouse Layout, Out of Block, Heuristic Approach, Shared Storage.

1. INTRODUCTION

PT. XYZ is an enterprise for sales services, maintenance, repair and spareparts provider of Toyota. To support its function, PT XYZ has regional parts depo Bandung, a distribution warehouse that supply spare parts product to the whole region of West Java. PT. XYZ has two types of warehouses, non-chemical and chemical warehouses. chemical warehouse is a warehouse with 86 m2 area that arranged floor storage stack based on the block allocated for the associated SKU. The problems experienced in chemical warehouse at the moment is the number of products that are not absorbed and stored off site storage. Conditions due to a few blocks overcapacity and several kinds of products that do not have a storage block.

However, based on the initial processing of existing data, the problems faced by PT XYZ was not caused by the condition of the warehouse that overcapacity, but rather due to imbalance of maximum inventory posistion (MIP) policy with the capacity that allocated to each product.As shown in Figure 1 , With existing layout and allocation, some product slot are overcapacity while some other slot have low utilities.

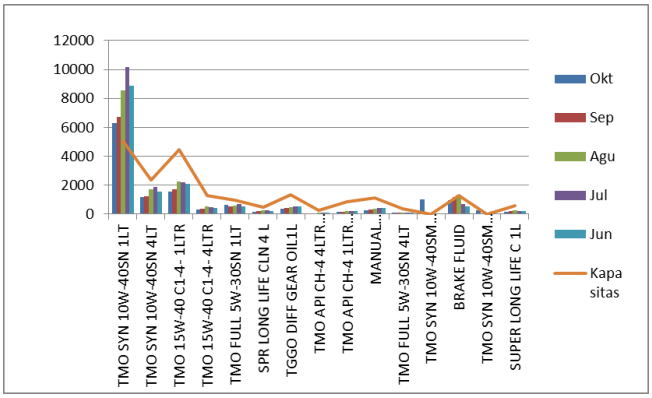


Figure 1:Comparison of MIP and Slot Capacity

Furthermore, company's dedicated storage policy in chemical warehouse made overcapacity slot product being placed out of block. And according to data from June until October in Figure 2, it shown that out of block product is around 30%.

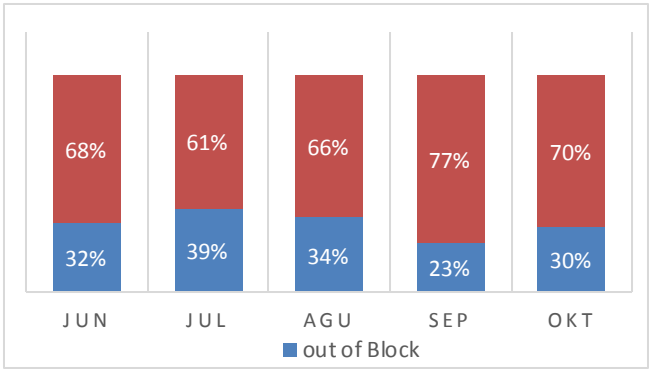


Figure 2: Out of Block Product

As the problems that has been explained, this paper will propose design of layout chemical warehouse PT XYZ using heuristical approach and shared storage method to reduce out of block product.

2. LITERATURE REVIEW

Many researcher have discussed the layout design problem in block stacking warehouse. Goetschalcks [2] in 1991 made a model of optimal lane depth for single and multiple products in block stacking storage system, the research conclude that an efficient block stacking warehouse layout will contain different lane depth for each product. Heuristic approach in warehouse design has been proposed by Larson [3] in 1996. The research presents a heuristic procedure for determining warehouse layout by using class-based storage rationale. However, in this research the heuristic approach is presented by propose some alternative with different lan depth and evaluate the capacity and out of block product by using shared storage method.

According to Larson[..], heuristic approach procedure being used to develop the warehouse layout to increase utility storage area in the warehouse. Procedure heuristic approach proposed by Larson consists of three phases. Phase 1, determining aisle layout and dimensions. This phase consists of several steps, starting from identification of alternative pathways aisle by minimizing the number of angle / distance curve and the calculation of the entrance and exit. The next determination of dimensions is done by finding the minimum aisle width requirement, slot dimensions and clearances required. The second phase is determining storage medium. This phase briefly consists of two steps, the first is the collection of data on average inventory level, the maximum and minimum heap (Palette), maximum and minimum values lane depth, of each type of product to be stored. Second, the application of row depth algorithm to obtain the number of store locations and lane depth of each type of product. And the last is allocating floor space.

Shared storage is allocation policy that combine randomized storage and dedicated storage. This policy reduces the maximum space required on a warehouse and increase the utility of the area that supplies (Francis & White, 1992). Total space requirement of shared storage policy revolves around the values possessed by the dedicated and rendomized storage. In general, shared storage policy can be applied to various modifications tailored to the needs and conditions of the company (Francis & White, 1992). In this research shared storage applied by allocating several kind of product (max.2) in a storage location to reduce storage location requirement in the warehouse.

3. RESEARCH METHODOLOGY

The conceptual model is the concept of thought that became a tool in the formulation of problem-solving research. the research about design of chemical warehouse layout XYZ is depicted in the conceptual model in Figure 3.

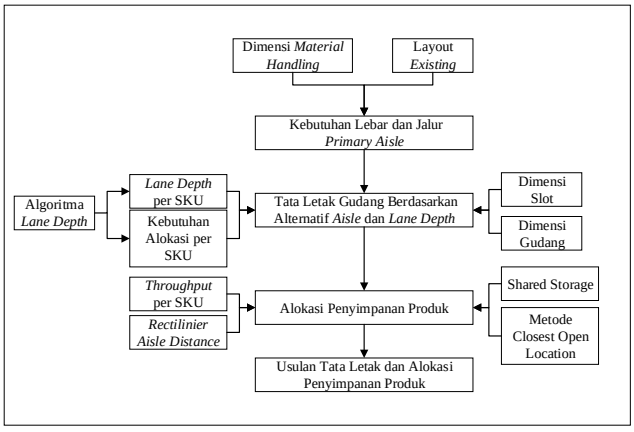


Figure 3: Conceptual Model

The data needed to determine the proposed layout and storage allocation in Chemical Warehouse PT. XYZ starts with meterial handling dimensions, existing layouts, and track aisle width requirement. Next, the calculation of lane depth algorithm is being done to get lane depth per SKU and number of location needed. Then, with addition of data slot dimension, alternatives of warehouse layout will be obtained. Next, product is allocated sequentially based on the data throughput zto the location with the closest distance based on calculations rectilinear aisle distance and method of shared storage. And last, proposed layout will be determined by calculate capacity and out of block product in each alternatives.

4. RESULT AND DISCUSSION

4.1 Layout Design and Allocation

1. Determining aisle layout and dimensions

Chemical warehouse XYZ uses forklift reach truck category with length and width dimensions of 1.8 m x 1.1 m. So by entering the value obtained that diagonal of material handling is 2,11 meter. While theory by Tompkins [..] in 2010, said that minimum aisle width for reach truck is 2,438 meter. Hence, theory by Tompkins for minimum aisle width will be chosen.

Slot dimensions determined adding the dimensions of pallets with allowance value according international standardization, as we seen in Figure 4.

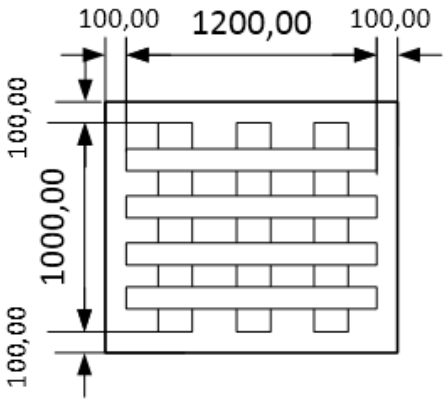


Figure 4: Slot Dimension (mm)

Next, lane depth maximum calculation is done by using equation:

- Horizontal *Primary Aisle*

$$\text{Wh Vertical width} = \textit{Aisle} + \text{Slot width} \,.\, (D_{max})$$

$$8{,}5 \text{ meter} = 2{,}438 \text{ meter} + 1{,}2 \text{ meter} \,.\, (D_{max})$$

$$D_{max} = 5$$

- Vertikal *Primary Aisle*

$$\text{Wh Horizontal width} = \textit{Aisle} + \text{Slot width} \,.\, (D_{max})$$

$$10 \text{ meter} = 2{,}438 \text{ meter} + 1{,}2 \text{ meter} \,.\, (D_{max})$$

$$D_{max} = 6$$

After getting the maximum lane depth of storage areas for each horizontal and vertical aisle, next, warehouse layout alternatives is conducted as Figure 5.

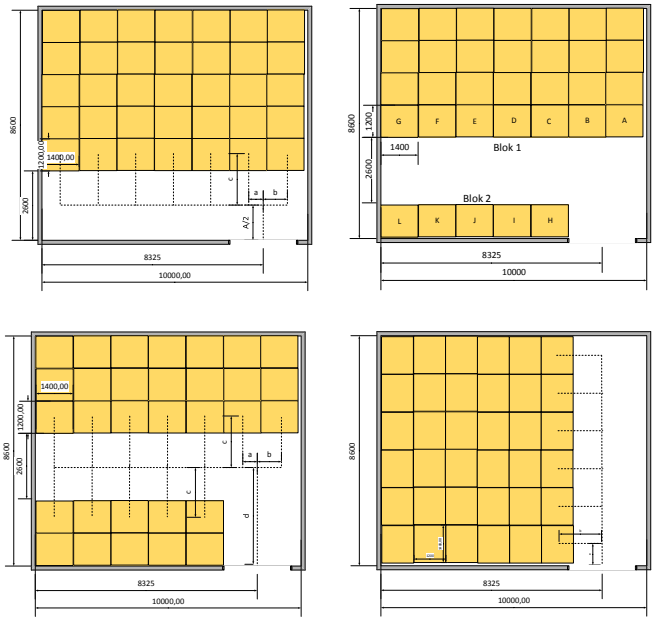


Figure 5: Layout Alternatives

By eliminating the other horizontal alternative that has same combination of lane depth but with a smaller capacity, then got three alternative layouts with horizontal aisle (code: H-depth) i.e H5, H 4-1, and H 3-2. While for vertical aisle, alternative V 6 which perpendicular to the doorway becomes the only option may be to minimize the amount of junction.

2. Determining storage medium

This phase is carried out to determine the optimum lane depth of each product to maximize the utility of each storage location. By using the row depth algorithm then the theoretical lane depth and number of storage locations for each product will be determined. Here is the notation that been used in row depth algorithm according to Larson in 2007:

n :Number of product stored in a warehouse
j :Number index for each product
hj :Policy number of piles for each product (j = 1, ..., n)
sj :Average inventory level of each product(j = 1, ..., n)
α :Percentage of allowance to honeycombing
hmin: Minimum stack height for floor stack
dmax: maximum stack depth for floor

dmin: minmum stack depth for floor
Nj :The number of storage locations required for each t ype of SKU (j = 1, ..., n)
Dj :Depth optimum for each type of product(j = 1, ..., n)
N * :The number of storage locations needed today
F (sj): The function of the use of allocated storage racks for each type of product

Input: n, hj, sj, α, hmin, dmax, dmin
Output: Nj, dj

Step 0. J = 1
Step 1. If hj <hmin, then go to step 5
If not, skip to step 2
Step 2. Compute N * = ⌈ (1 + α) sj / (dmax hj) ⌉
Calculate dj = ⌈ (1 + α) sj / (N * hj) ⌉
Step 3. If dj ≥ dmin, then go to step 4
If not, go to step 5
Step 4. Calculate Nj = ⌈ (1 + α) sj / (dj hj) ⌉, go to step 6
Step 5. dj = 0, Nj = F (sj)
Step 6. If j <n
j = j + 1, go to step 1
If not, Stop

In Table 1 and Table 2, by calculating the row depth algorithm ,lane depth optmum depth and number of storage locations will be obtained for each product in every alternate layout

Table 1: Row depth algorith result (H5 & H4-1)

No	Material number	H 5 *depth*		H4-1 *depth*	
		dj	Nj (S)	dj	Nj (S)
1	08880-83575	4	3	4	3
2	08880-83576	3	2	3	2
3	08880-83351	2	1	2	1
4	08880-83352	3	1	3	1
5	08880-83573	1	1	1	1
6	08889-80090	2	1	2	1
7	08885-80930	1	1	1	1
8	08880-80421	1	1	1	1
9	08880-80420	1	1	1	1
10	08885-80929	1	1	1	1
11	08880-83574	1	1	1	1
12	08880-83220	1	1	1	1
13	08823-80011	1	1	1	1
14	08880-83221	1	1	1	1
15	08889-80100	1	1	1	1

Table 2: Row depth algorith result (H3-2 & V6)

No	Material number	H 3-2 *depth*		V6 *depth*	
		dj	Nj (S)	dj	Nj (S)
1	08880-83575	3	4	6	2
2	08880-83576	3	2	6	1
3	08880-83351	2	1	2	1
4	08880-83352	3	1	3	1
5	08880-83573	1	1	1	1
6	08889-80090	2	1	2	1
7	08885-80930	1	1	1	1
8	08880-80421	1	1	1	1
9	08880-80420	1	1	1	1
10	08885-80929	1	1	1	1
11	08880-83574	1	1	1	1
12	08880-83220	1	1	1	1
13	08823-80011	1	1	1	1
14	08880-83221	1	1	1	1
15	08889-80100	1	1	1	1

3. Allocating floor space

To perform storage allocation,its necessary to know the distance between each storage location to the point of I / O. Hence, by using the calculation rectilinier aisle distance, then the distance will be obtained within the storage location of each alternative layout to the point I / O on the Table 3.

Tabel 3: Rectilinier aisle distance (mm)

Blok	Lane	Horizontal 5 *depth*	Horizontal 4-1 *depth*	Horizontal 3-2 *depth*	Vertikal 6 *depth*
1	A	3975	4175	5375	2625
	B	3825	5025	6225	4025
	C	5225	6425	7625	5425
	D	6625	7825	9025	6825
	E	8025	9225	10425	8225
	F	9425	10625	11825	9625
	G	10825	12025	13225	-
2	H	-	6425	7625	-
	I	-	7825	9025	-
	J	-	9225	10425	-
	K	-	10625	11825	-
	L	-	12025	13225	-

Next, by sorting products based on the ratio of throughput/storage from largest to smallest as we seen in Table 5, now the product can be allocated sequentially to the closest distance.

Table 5: Ranking Rasio T/S

Mat.num	Ranking Rasio T/S				MIP (Palet)
	H 5	H4-1	H3-2	V 6	
08880-83575	1	1	4	2	43
08880-83576	3	3	2	1	24
08880-83351	4	4	3	4	10
08880-83352	6	6	6	6	7
08880-83220	2	2	1	3	5
08880-83221	5	5	5	5	4
08889-80090	7	7	7	7	4
08880-83573	8	8	8	8	3
08823-80011	9	9	9	9	3
08885-80930	10	10	10	10	3
08885-80929	11	11	11	11	2
08880-83574	12	12	12	12	2
08880-80421	13	13	13	13	2
08889-80100	14	14	14	14	2
08880-80420	15	15	15	15	1

Table 6: Result of storage allocation

No	Material number	Lokasi Simpan (*Lane*)			
		Horizontal *5 depth*	Horizontal *4-1 depth*	Horizontal *3-2 depth*	Horizontal *6 depth*
1	08880-83575	A,B,C	A,B,C	A,E,F,G	B,C
2	08880-83576	D,E	D,E	B,C	A
3	08880-83351	E	F	D	D
4	08880-83352	F	E	I	E
5	08880-83573	C	C	A	C
6	08889-80090	F	H	H	D
7	08885-80930	G	I	H	E
13	08823-80011	-	L	L	-
14	08880-83221	-	L	L	-
15	08889-80100	-	J	I	-

Based on the order of the rasio T/S, the product is placed from the point with the smallest distance that can accommodate products and adapted to the number of storage locations predetermined. If the location has been filled with one type of product, the slot can still be filled with other types of products that can be accommodated according to the procedure beforehand. The result of allocation can be seen in Table 6.

4.2 Warehouse Space Utilization

Warehouse space utilization is the ratio between the unused warehouse area in comparison to the total warehouse area. The formula for calculation is :

$$\% \text{ Space utilization} = \frac{storage\ area}{\text{Total Warehouse area}}\ x\ 100\%$$

$$\% \text{ Space utilization} = \frac{24 \text{ x } (1{,}4 \text{ x } 1{,}2)}{86}\ x\ 100\%$$

By using the formula, existing and each alternative layout space utilization can be determined.as follows.

$$\text{Existing \% Space utilization} = \frac{24 \text{ x } (1{,}4 \text{ x } 1{,}2)}{86}\ x\ 100\%$$

$$\text{Existing \% Space utilization} = 47\%$$

$$\text{Alt H5 \% Space utilization} = \frac{35 \text{ x } (1{,}4 \text{ x } 1{,}2)}{86}\ x\ 100\%$$

$$\text{Alt H5 \% Space utilization} = 69\%$$

$$\text{Alt H4-1 \% Space utilization} = \frac{33 \text{ x } (1{,}4 \text{ x } 1{,}2)}{86}\ x\ 100\%$$

$$\text{Alt H4-1 \% Space utilization} = 65\%$$

$$\text{Alt H5 \% Space utilization} = \frac{31 \text{ x } (1{,}4 \text{ x } 1{,}2)}{86}\ x\ 100\%$$

$$\text{Alt H5 \% Space utilization} = 61\%$$

$$\text{Alt H5 \% Space utilization} = \frac{36 \text{ x } (1{,}4 \text{ x } 1{,}2)}{86}\ x\ 100\%$$

$$\text{Alt H5 \% Space utilization} = 71\%$$

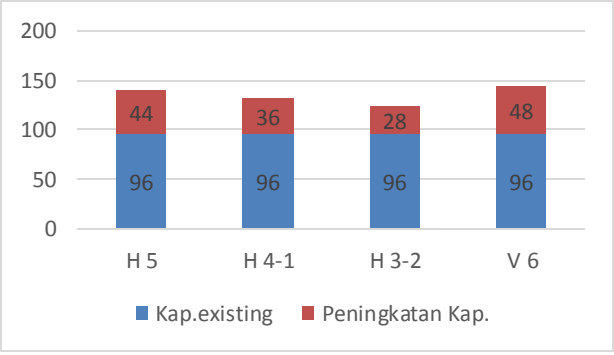


Figure 6: Capacity Improvement

Based on the calculation of space utilization on each layout alternative obtained that each alternative experiencing better utilization than the existing condition. The increase in utilization due to increasing the number of slots would increase the capacity of the warehouse as we seen in Figure 6.

4.2 Out of Block Product

Calculation of product out of block on the alternative made by counting the number of products which can not be accommodated at this stage of storage allocation. With the condition of the products must be stored amounts to 115 pallet positions based on Table 7.

Table 7: Maximum agregate of MIP

No	Material number	Maximum *Inventory* Position (Palet)					
		Okt	Sep	Agu	Jul	Jun	Max
1	08880-83575	27	29	36	43	37	43
2	08880-83576	16	16	22	24	20	24
3	08880-83351	7	8	10	10	9	10
4	08880-83352	4	5	7	6	6	7
5	08880-83573	3	3	3	3	3	3
6	08889-80090	3	3	4	4	3	4
7	08885-80930	2	2	3	3	3	3
8	08880-80421	1	1	1	2	2	2
9	08880-80420	1	1	1	1	1	1
10	08885-80929	2	2	2	2	2	2
11	08880-83574	1	1	2	2	2	2
12	08880-83220	5	0	0	0	0	5
13	08823-80011	3	3	3	2	2	3
14	08880-83221	4	0	0	0	0	4
15	08889-80100	1	1	2	1	1	2
	Total	80	75	96	103	91	**115**

After calculating out of the block product for each alternative, it is known that the four alternatives has decreased the number of products out of blocks. Furthermore, alternative H3-2 and alternative H4-1 depth is able to reduce the number of products out of block down to 0%. The result of out of block product and the comparison with existing condition can be seen at Figure 8.

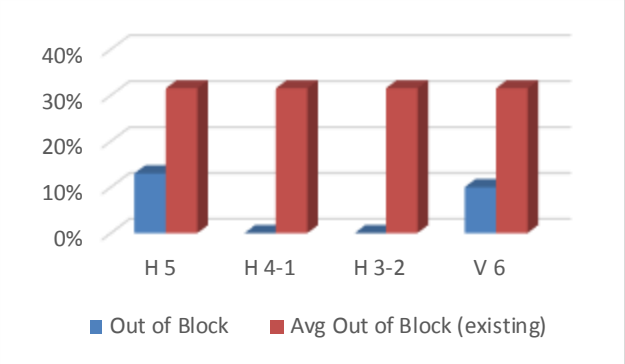


Figure 8: Out of Block Product in each alternative

4.2 Selection of Proposed Layout

Selection of warehouse layout proposals made by formulating an objective function that maximizes the amount of capacity that can be accommodated by making the number of store locations as a restraint so that the products are not placed out of the block:

Objectie Fuction:

$$Maximize \quad \sum_{i=1}^{m} L_{ij} \cdot d_{ij} \cdot h$$

Contraint:

$$\sum_{k=1}^{15} N_k \leq n \cdot \sum_{i=1}^{m} L_{ij}$$

$$d_{1j} + d_{2j} \leq 5 \text{ (for } j = 1,2,3)$$

$$d_{i4} = 0 \text{ (for } i = 1,2)$$

$$d_{34} \leq 6$$

In the process of selecting the best layout, objective function is set to maximize the number of slots used as a measure of the capacity of the warehouse. Maximizing the depth of the lane is done by multiplying each block in each alternative, with the number of lane in each block contained in the side aisle. Furthermore, each alternative was also tested with contraint which requires the number of store locations are required to have a value that is smaller than the multiplication of the number of lane total by the number of store locations per-lane. Thus, the solution will be proposed layout is a solution that does not violate the contraint and has the highest value of the objective function

1. Horizontal 5 (j=1)

$$Maximize \quad \sum_{i=1}^{m} L_{ij} \cdot d_{ij} \cdot h$$

$$7 \cdot 5 \cdot 4$$

140 Palet

Contraint:

- $\sum_{k=1}^{15} N_k \leq n \cdot \sum_{i=1}^{m} L_{ij}$

$18 \leq 2.\ (7)$

$18 \not\leq 24$ (Not feasible)

- $d_{11} + d_{21} \leq 5$

  $5+0 \leq 5$

2. Horizontal 4-1 (j=2)

   Maximize $\sum_{i=1}^{m} L_{ij} . d_{ij} .h$

   $7 . 4. 4 + 5 . 1. 4$

   132 Palet

   Contraint:

   - $\sum_{k=1}^{15} N_k \leq n . \sum_{i=1}^{m} L_{ij}$

     $18 \leq 2.\ (7+5)$

     $18 \leq 24$ (Feasible)

   - $d_{12} + d_{22} \leq 5$

     $4+1 \leq 5$

3. Horizontal 3-2 (j=3)

   Maximize $\sum_{i=1}^{m} L_{ij} . d_{ij} .h$

   $7 . 3. 4 + 5 . 2. 4$

   124 Palet

   Contraint:

   - $\sum_{k=1}^{15} N_k \leq n . \sum_{i=1}^{m} L_{ij}$

     $18 \leq 2.\ (7+5)$

     $18 \leq 24$ (Feasible)

   - $d_{13} + d_{23} \leq 5$

     $3+2 \leq 5$

4. Vertikal 6 (j=4)

   Maximize $\sum_{i=1}^{m} L_{ij} . d_{ij} .h$

   $6 . 6. 4$

   144 Palet

   Fungsi Pembatas:

   - $\sum_{k=1}^{15} N_k \leq n . \sum_{i=1}^{m} L_{ij}$

     $18 \leq 2.\ (6)$

     $18 \not\leq 12$ (Not feasible)

   - $d_{34} \leq 6$

Based on calculations, it was found that the only two alternative that feasible are Horizontal 4-1 and 3-2. The maximum objective function value obtained from alternative Horizontal 4-1 with a total of 33 slots, therefore the alternative is selected as the best proposed layout.

4. CONCLUSION

Based on the research objectives that have been submitted, the conclusions of this study are: The best proposed layout design for chemical warehouse XYZ is the layout with horizontal aisle and lane depth 4-1 slots. The proposed layout in Figure 9 has been proved to increase capacity by 27 % to 132 pallet positions and eliminate the number of products out of the block to 0%..

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