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Analysis Planning Relay Layout with Computerized Relative Allocation of Facilities Technique Approach

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Abstract

PT XYZ is one of the manufacturing industries engaged in the production of palm oil processing. The products produced are cooking oil and margarine. So far, the implementation of activities has been hampered by the current layout conditions having a less efficient material handling path length, in addition, the distance between facilities is too far ± 150m which results in repeated transportation, this results in PT XYZ's material transfer activities being less effective. Therefore, this study aims to redesign the layout of production facilities in order to minimize material handling costs and raw material movement distances to be more effective. From these problems, the method used is the CRAFT (Computerized Relative Allocation of Facilities Techniques) method, this method can be done with the help of FTC (From to Chart), ARC (Activity Relation Chart) and ARD (Activity Relationship Diagram) calculations. The results of this study showed that the CRAFT algorithm succeeded in saving total material handling costs of Rp. 469,352.04 per day and reducing the total distance of movement by 67.15 meters. The reduction in material handling costs achieved was Rp 2,114,734.77 or around 81.84%, while the reduction in material handling distance reached 306.85 meters or around 82.05%.

Introduction

The development of industry in the era of globalization has an impact on many large companies, both advanced and developing companies. Companies are required to always compete in improving the quality of production results. This is done by increasing the efficiency and effectiveness of the company which aims to reduce waste in the company. Parameters that are often used to measure the efficiency aspect while still considering the effectiveness aspect in achieving company goals with productivity. One way to increase productivity is by designing an efficient and optimal layout (Kamaruddin et al., 2011; Prijanisa et al., 2024). In the context of designing a facility layout, efficient material transfer can reduce the distance, time, and costs involved, which directly impacts the company's productivity and profits (Cano et al.,2021; Abdul Rahman et al., 2023; Mourato et al., 2021).

Material handling system can be defined as the selection and arrangement of handling devices along the material handling path to reduce MHC (Hutabarat, 2022). MHC in a factory takes place around 40-70 times or 50%-70% of all production activities. The costs incurred from the material transfer process are around 75% of the total production costs incurred (Nurahman, 2021; Hartini et al., 2023). If the facilities are arranged effectively, the company can reduce these costs by at least 10-30% and increase their productivity.

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PT XYZ is one of the manufacturing industries engaged in the production of palm oil processing. The products produced are cooking oil and margarine. In carrying out its production activities, PT XYZ is inseparable from productivity problems. For the sake of smooth production flow, it is very much determined by the existence of procedures for arranging facilities with the aim of arranging production areas and all the most economical facilities for production operations (Maimon et al., 1998; Saputra, 2019). So far, the implementation of activities has been hampered because the current layout conditions have a long and inefficient material handling path, this has resulted in PT XYZ's material transfer activities being less effective. In addition, the distance between facilities is too far ± 150m which results in repeated transportation (Pitale et al., 2022). Because the distance of the process flow path in the current production facility is still not good with the use of areas that are not optimal and the placement of several existing facilities is quite far apart so that the distance of the path between work units and the process of moving goods becomes less efficient (Fajarika et al., 2019; Sihombing et al., 2023). Based on the above problems, efforts are needed to improve the smoothness of production with the layout of facilities with the CRAFT (Computerized Relative Allocation of Facilities Techniques) method, this method evaluates and rearranges the layout of facilities (relayout) so as to minimize the total moment of distance of movement and minimize material handling costs (Wali & Lukmandono, 2023; Siagian et al., 2022; Noer et al., 2024; Rachmawaty et al., 202) and to align the CRAFT (Computerized Relative Allocation of Facilities Techniques) method, this method can be done with the help of FTC (From to Chart), ARC (Activity Relation Chart) and ARD (Activity Relationship Diagram) calculations. With the proposed CRAFT method, it is hoped that PT XYZ can minimize material handling costs and the distance of movement of raw materials to be more effective.

Methods

Method Computerized Relative Allocation of Facilities Technique (CRAFT) is a method repair in designing optimally in the layout improvements carried out in a way gradually. Since 1983, method This capable improve layout department with consider the size of a certain area (Kulsum & Tola, 2019).

Following This is steps in preparation design layout improvements facility line production flooring: 1) Do studies literature from study previously; 2) Do data collection with method observation field and interviews with party underwriter answer PT XYZ production. Collected data among them namely dimensional data facilities, production data, frequency data activity material handling, and data layout beginning; 3) Count distance travel material handling production use approach Rectilinear.

$$dij = | Xi - Xj | + | Yi - Yj |$$

Count fare material handling per meter (OMH/m) with formula: a) OMH/meter = OMH of the device transport / Distance Total displacement

Create Activity Relationship Chart (ARC) and Activity Relationship Diagram (ARD) maps between station Work. Inputting input data includes that is code department, location fixed every department, cost matrix every department, and point coordinate from each department. in the CRAFT algorithm program. After inputting the input data Then done iteration by the CRAFT algorithm program so that layout is generated new.

Results and Discussion

On research This collected data is layout existing facility production, size facilities used like wide building / department, production process flow, equipment *material handling*, costs *material handling.*

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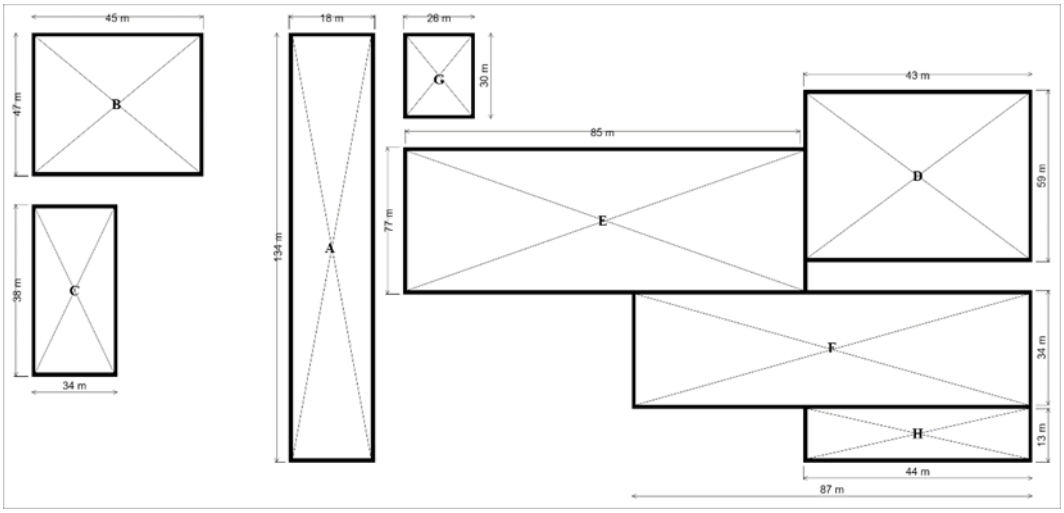

Figure 1. Layout of PT XYZ

For makes it easier reading on calculations so each station Work symbolized with alphabetic symbols, as following :

Table 1. PT XYZ Layout Symbols

Code	Facilities / Departments
A	CPO Tank
B	Refinery and Fractionation
C	New Storage Tank
D	Fatty Acid Tank
E	Margarine Plant
F	Goods Warehouse So (Margarine)
G	QC Lab
H	Office

Source: Processed Data, 2024

Measurement Distance between Facilities / Departments

In count distance between location in the production process margarine, used method *rectilinear*. Following is information about distance between facility production. Measurement results distance between facilities / departments at PT XYZ

Table 2. Distance Between Layout Facilities Beginning

From	Coordinate Center Point		To	Coordinate Center Point		Distance (m)
	X	Y		X	Y	
A	63	58	B	88	18	65
B	88	18	C	55	8	43
C	55	8	D	75	145	157
D	75	145	E	68	98	54
E	68	98	F	45	130	55
F	45	130				
G						
H						
	Total					374

Source: Processed Data, 2024

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Following is example calculation distance between facility / department use method *rectilinear* :

Distance Between Station AB work

$$D_{AB} = |X_A - X_B| + |Y_A - Y_B|$$
$$= |63 - 88| + |58 - 18|$$
$$= 65 \text{ m}$$

Calculation Tool *Material Handling*

Wages For one employee per month is Rp 4,725,479 per month , converted into the salary per day, with 24 days effective work and working hours for the production process for 7 hours of time effective, so cost per day IDR 196,894 per day.

Material handling use pump

Cost depreciation = IDR 154,109.59 per day

Cost maintenance = IDR 59,027.78 per day

Cost material fuel (electricity) = 109,641.4 per day

Cost total operational equipment pump

= Labor Costs + Costs Maintenance + Cost material burn + Cost depreciation

= IDR 196,894 + IDR 59,027.78 + IDR 109,641.4 + IDR 154,109.59

= IDR 519,672.97 per day

Material handling use conveyor

Cost depreciation = IDR 123,287.67 per day

Cost maintenance = IDR 80,555.56 per day

Cost material fuel (electricity) = 104,657.7 per day

Cost total operational equipment conveyor

= Labor Costs + Maintenance Costs + Costs material burn + Cost depreciation

= IDR 196,894 + IDR 80,555.56 + IDR 104,657.7 + IDR 123,287.67

= IDR 505,394.93 per day

Calculation *Cost Material* Handling Layout Beginning

Total cost *material handling* determined from big fare *material handling* each unit size deep displacement study This called with fare *material handling* per meter (OMH/meter). The OMH/meter value will be will used as *input* to in *cost matrix* in the CRAFT algorithm.

Table 3. OMH/meter *Material Handling* Beginning

From	To	Distance (m)	Frequency / day	Tool *Material Handling*	Cost / meter	Cost / day
A	B	65	3	Pump	Rp. 2,664.99	Rp. 519,672.97
B	C	43	3	Pump	Rp. 4,028.47	Rp. 519,672.97
C	D	157	3	Pump	Rp1,103.34	Rp519,672.97
D	IN	54	3	Pump	Rp3,207.86	Rp519,672.97
IN	F	55	100	Conveyor	Rp91.89	Rp505,394.93
Total		374	112		Rp11,096.55	Rp2,584,086.81

Source: Processed Data, 2024

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Example calculation Initial *material handling costs* :

$$\text{OMH/meter A to B} = \frac{\text{Biaya Operasional per Hari}}{\text{Total Jarak Perpindahan (meter)}}$$

$$= \frac{\text{Rp } 519.672{,}97}{65 \times 3}$$

= IDR 2,664.99 / meter

Table 4. FTC OMH/meter calculation

From To Chart								
	Ke	**A**	**B**	**C**	**D**	**E**	**F**	
From	**Department**	**(Tanki CPO)**	**(Refinery dan Fraksinasi)**	**(New Storage Tank)**	**(Tanki Fatty Acid)**	**(Margarine Plant)**	**(Finished Goods Warehouse)**	**Total**
A	(Tanki CPO)		Rp 2,664.99					Rp 2,664.99
B	Refinery dan Fraksinasi			Rp 4,028.47				Rp 4,028.47
C	New Storage Tank				Rp 1,103.34			Rp 1,103.34
D	Tanki Fatty Acid					Rp 3,207.86		Rp 3,207.86
E	Margarine Plant						Rp 91.89	Rp 91.89
F	Finished Goods Warehouse							0
Total		**Rp 2,664.99**	**Rp 4,028.47**	**Rp 1,103.34**	**Rp 3,207.86**	**Rp 91.89**		**Rp 11,096.55**

Processing Proximity between Facility

Activity Relationship Chart

ARC helps identify and visualize closeness and dependence that can be make it easier in determine optimal placement of every activity.

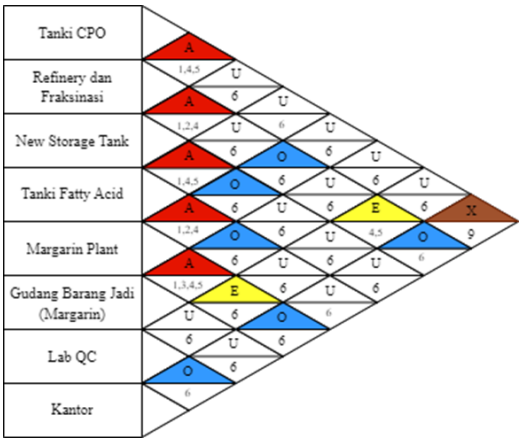

Figure 2. Activity Relationship Chart

Activity Relationship Diagram

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Activity Relationship Diagram (ARD) is a visual diagram used For describe relationships and interactions between location or facilities on a layout . Before create ARD, necessary do recap of the data obtained from ARC.

Table 5. Recap of ARC Data

Kode	Facilities/Departments	Degree of Proximity	A	E	I	O	U	X
A	Tanki CPO		B			B,C,D,E,F,G		H
B	Refinery dan Fraksinasi		C			E,H	D,F	
C	New Storage Tank		D			E	F,G,H	
D	Tanki Fatty Acid		E				F,G,H	
E	Margarine Plant		F	G			G,H	
F	Finished Goods Warehouse (Margarine)						G,H	
G	Lab QC							
H	Office							

After grouping every connection between facility based on degrees proximity, step furthermore is draw a proximity diagram. Diagram will depicted in accordance with degrees assessment given. Following This is ARD results for PT XYZ facilities / departments.

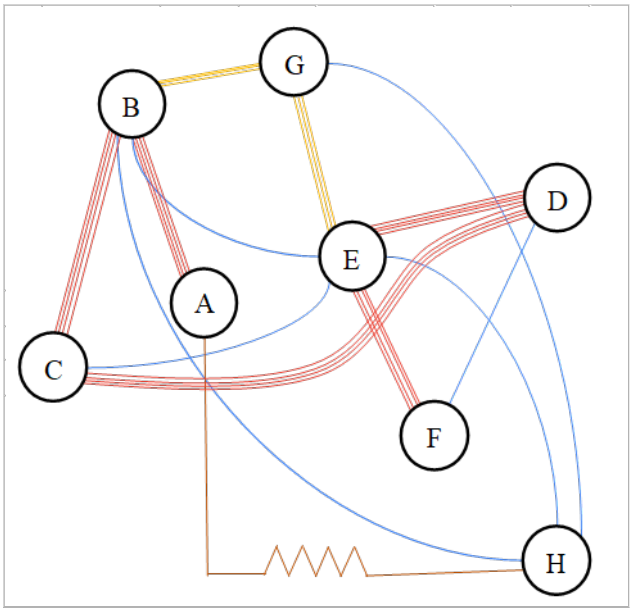

Figure 3. Activity Relationship Chart

Metode CRAFT

Layout design use CRAFT algorithm is performed with help *winQSB software*. First thing to do namely initial data input CRAFT algorithm with Enter the initial data in the available tables which are then the initial data will analyzed For produce *layouts* proposal.

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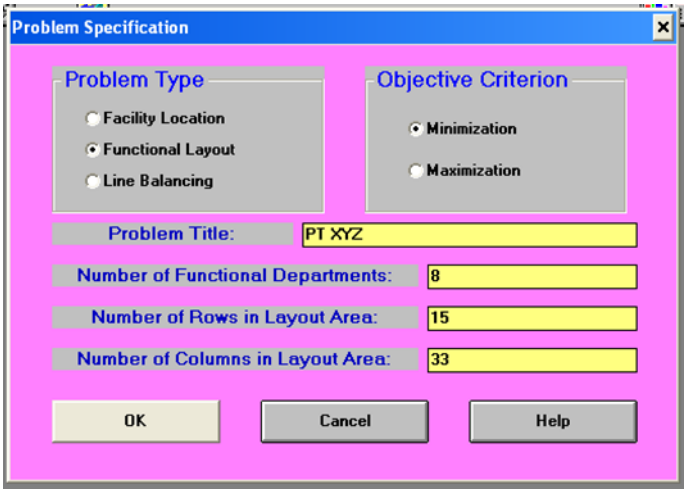

Figure 4. Display of the WINQSB Problem Specification software program

Functional Layout Information for PT XYZ

1 : Location Fixed | No

Department Number	Department Name	Location Fixed	To Dep. 1 Flow/Unit Cost	To Dep. 2 Flow/Unit Cost	To Dep. 3 Flow/Unit Cost	To Dep. 4 Flow/Unit Cost	To Dep. 5 Flow/Unit Cost	To Dep. 6 Flow/Unit Cost	To Dep. 7 Flow/Unit Cost	To Dep. 8 Flow/Unit Cost
1	A	No		2664.99						
2	B	No			4028.47					
3	C	No				1103.34				
4	D	No					3207.86			
5	E	No						91.89		
6	F	No								
7	G	No								
8	H	No								

Functional Layout Information for PT XYZ

6 : To Dep. 4 Flow/Unit Cost

Department Number	To Dep. 2 Flow/Unit Cost	To Dep. 3 Flow/Unit Cost	To Dep. 4 Flow/Unit Cost	To Dep. 5 Flow/Unit Cost	To Dep. 6 Flow/Unit Cost	To Dep. 7 Flow/Unit Cost	To Dep. 8 Flow/Unit Cost	Initial Layout in Cell Locations [e.g., (3,5), (1,1)-(2,4)]
1	2664.99							(1,11)-(15,13)
2		4028.47						(1,1)-(5,7)
3			1103.34					(7,1)-(12,3)
4				3207.86				(3,26)-(8,33)
5					91.89			(5,15)-(9,25)
6								(10,20)-(13,33)
7								(1,15)-(3,18)
8								(14,26)-(15,33)

Figure 5. Functional Layout Information

In determination *functional layout information*, this contains about code department, *location fixed* every department, *cost matrix* every department, and point coordinate from each department. That matter aim For determine total *cost* and layout department in each iteration *layout* that will made.

In study This is for determine type layout exchange use *software* WinQSB there is four type that is *Improve by Exchanging* 2 *Departments*, *Improve by Exchanging* 3 *Departments*, *Improve by Exchanging* 2 *then* 3 *Departments*, and *Improve by Exchanging* 3 *then* 2 *Departments*. Entire type the can used in the method measurement distance (*distance measure*) such as *Rectilinear Distance*. This matter aims to be able to determine layout type farm with fare displacement minimum *material handling.*

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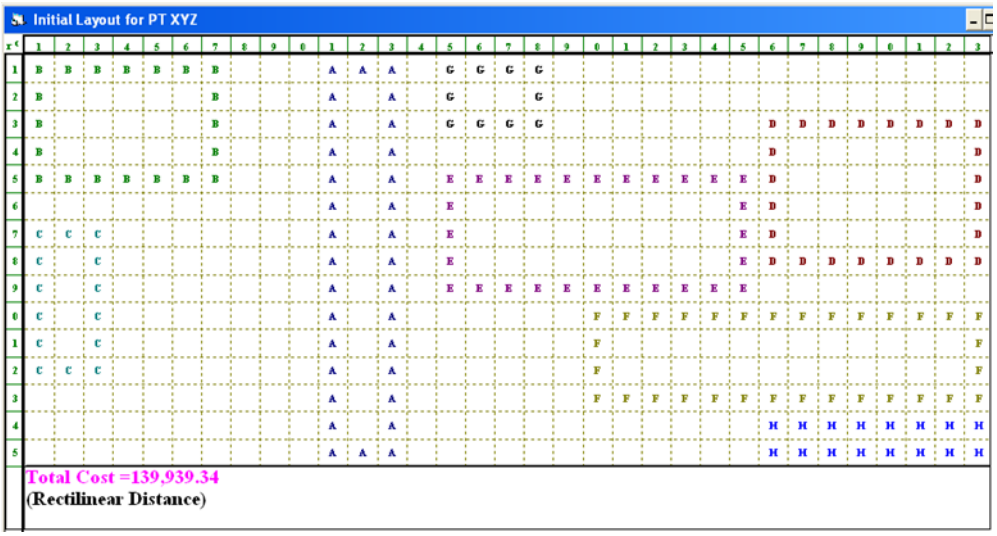

Figure 6. Initial Layout

In *initial evaluate layout*, layout beginning evaluated until until *final layout*. And evaluate the layout the shown through iteration iteration *layouts*.

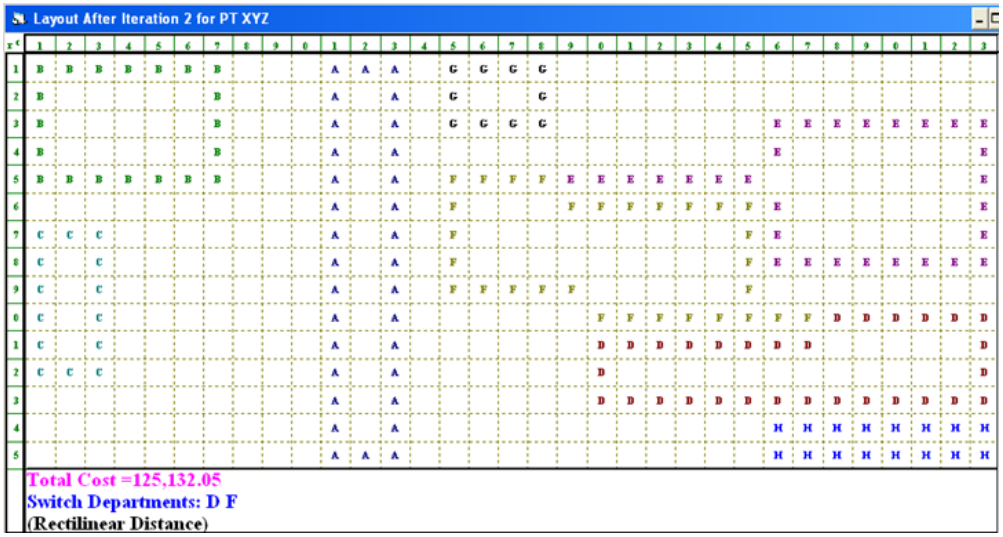

Figure 7. Final Layout

Based on a number of determination *final layout* with fourth CRAFT algorithm *solution* there are, you can known that there is difference mark cost displacement *material handling*. Following is explanation OMH *final layout* results can seen in the table following:

Table 6. OMH Results of the CRAFT Algorithm

Solution CRAFT algorithm	Iteration	Moment Distance	Total cost Material Movement
Evaluate The Initial Layout	0	1020 m	Rp. 139,939.34
Improve by Exchanging 2 Departments	2	1015.48 m	IDR 125,132.05
Improve by Exchanging 3 Departments	0		Rp 139.939,34
Improve by Exchanging 2 then 3 Departments	2	1015,48 m	Rp 125.132,05
Improve by Exchanging 3 then 2 Departments	2	1015,48 m	Rp 125.132,05

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Source: Processed Data, 2024

From the results OMH comparison, shows that method measurement distance use *rectilinear distance*, on *solution improve by exchanging* 2 *departments*, *improve by exchanging* 2 *then* 3 *departments* and *improve by exchanging 3 then 2 departments* own mark fare minimum *material* handling in comparison *solution improve by exchanging* 3 *departments*. If compare OMH value in *initial layout* and fourth type *functional layout solution*, then OMH value in *solution improve by exchanging* 2 *departments*, *improve by exchanging* 2 *then* 3 *departments* and *improve by exchanging 3 then 2 departments* own level decrease in OMH Rp. 125,132.05 ie amounted to 10.58%, meanwhile *improve by changing* 3 *departments* No experience decrease in OMH, because No happen iteration. For the total distance on *the layout* end from *solutions improve by exchanging* 2 *departments improve by exchanging* 2 *then* 3 *departments* and *improve by exchanging 3 then 2 departments* own decline the same distance that is amounting to 1015.48 meters and *improve by exchanging* 3 *departments* has the total distance in the final *layout* of 1020 meters. Based on fourth comparison that, then *layouts* end at facility / department selected PT XYZ production that is *layouts* end from *solutions improve by exchanging* 2 *departments*, *improve by exchanging* 2 *then* 3 *departments* and *improve by exchanging 3 then 2 departments.*

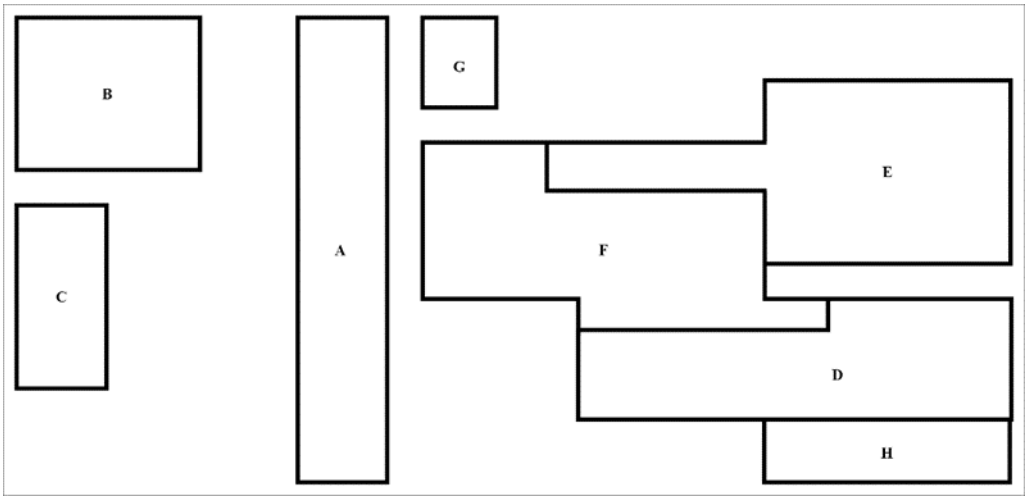

Figure 8. Proposed Layout

Measurement Distance between Facilities / Departments

Once done analysis between facility / department the production that the material goes through from *layouts* proposal use *WINQSB software*. So, step furthermore is do calculation distance between facility / department production *layouts* proposal.

Table 7. Distance Between Layout Facilities Proposal

From	Coordinate Center Point		To	Coordinate Center Point		Distance (m)
	X	Y		X	Y	
A	8	12	B	3	4	13
B	3	4	C	9,5	2	8,5
C	9,5	2	D	11,75	27	27,25
D	11,75	27	E	5,44	28,55	7,86
E	5,44	28,55	F	7,68	20,25	10,54
F	7,68	20,25				
G	2	16,5				
H	14,5	29,5				
	Total					**67.15**

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Source: Processed Data, 2024

Following is example calculation distance between facility / department suggestion :

Distance Between Station AB work

$$D_{AB} = |X_A - X_B| + |Y_A - Y_B|$$
$$= |63 - 88| + |58 - 18|$$
$$= 65 \text{ m}$$

Calculation *Cost Material* Handling Layout Proposal

Once obtained results from distance proposed material movement, then done calculation cost *material handling* layout new proposal.

Table 8. Calculations *Material Handling Costs* Proposal

From	To	Distance (m)	Frequency / day	Tool *Material Handling*	Cost / meter	Cost / day
A	B	13	3	Pump	Rp. 2,664.99	Rp. 103,934.61
B	C	8.5	3	Pump	Rp. 4,028.47	Rp. 102,725.99
C	D	27.25	3	Pump	Rp. 1,103.34	Rp. 90,198.05
D	E	7.86	3	Pump	Rp. 3,207.86	Rp. 75,641.34
E	F	10.54	100	Conveyor	Rp91.89	Rp. 96,852.06
Total		**67.15**			**Rp. 11,096.55**	**Rp. 469,352.04**

Source: Processed Data, 2024

Example calculation *cost material handling* Proposal :

OMH/ day A to B =OMH/meters x frequency x distance

=Rp 2.664,99 x 3 x 13

= IDR 103,934.61 / day

From the results The proposed OMH calculation is carried out , the total costs incurred per meter that is as big as Rp. 11,096.55, total cost per day IDR 469,352.04 and total distance between his department namely 67.15 meters.

Comparison *Layouts* Start and *Layout* Proposal

Based on existing processing and analysis done , got comparison between *layouts* initial and proposed *layout*.

Table 9. Comparison *Layouts* Start and *Layout* Proposal

Information	*Layouts* Beginning	*Layouts* Proposal	Difference (%)
Total Distance	374 meters	67.15 meters	82.05%
OMG	IDR 2,584,086.81	IDR 469,352.04	81.84%

Source: Processed Data, 2024

From the table above can known that happen subtraction distance material travel and costs *material handling* on *layout* proposal. The CRAFT algorithm worked save distance

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displacement of 82.05% and costs *material handling* amounting to 81.84%. And you can the difference is also known comparison from distance the distance the intermediate material travels *layouts* start and *layout* proposal. *Layouts* start and *layout* proposal own difference distance between station Work that is of 306.85 meters.

Discussion

The results and discussions obtained when determining the layout of facilities using the CRAFT algorithm method are in the solution improve by exchanging 2 departments, the CRAFT algorithm through 2 iterations only produces a final layout solution with a total final layout cost of Rp125,132.05 with a displacement distance of 1015.48 meters. For improve by exchanging 3 departments, the CRAFT algorithm does not iterate, this is because there is no exchange of departments that is profitable or results in cost reductions in department transfers, with a total final layout cost of Rp139,939.34 and a displacement distance of 1020 meters. For improve by exchanging 2 then 3 departments, the layout and iteration results are the same as improve by exchanging 2 departments, the reason is because there are no departments to be exchanged, so only 3 departments are exchanged at once, with a total final layout cost of Rp125,132.05 and a displacement distance of 1015.48 meters. Meanwhile, for improve by exchanging 3 then 2 departments, the layout and iteration results are the same as improve by exchanging 2 departments and improve by exchanging 2 then 3 departments through 2 iterations, producing the final layout solution with a total final layout cost of Rp125,132.05 and a displacement distance of 1015.48 meters.

Thus, the selected department exchange alternatives are improve by exchanging 2 departments, improve by exchanging 2 then 3 departments and improve by exchanging 3 then 2 departments, because they produce the smallest total cost and displacement distance. From this layout, the total real material handling cost is Rp469,352.04 per day and the total real distance is 67.15 meters. It can be seen that in this proposed layout there is a reduction in material handling costs and material handling distance from the initial layout. The reduction in material handling costs that occurred was Rp. 2,114,734.77, which is 81.84%, and the reduction in material handling distance that occurred was 306.85 meters, which is 82.05%.

Conclusion

Based on the results of the analysis and discussion, calculations using the CRAFT algorithm through the WINQSB software have been carried out in 2 iterations, resulting in the best layout proposal. Several facility or department positions are proposed to be changed, such as replacing the position of the Fatty Acid Tank (D) with the Finished Goods Warehouse (F), and exchanging the Margarine Plant (E) with the Fatty Acid Tank (D) to increase the effectiveness of material transfer. This layout proposal has succeeded in reducing the cost and distance of material handling compared to the initial layout. The CRAFT algorithm has succeeded in saving the total cost of material handling by Rp 469,352.04 per day and reducing the total distance of movement by 67.15 meters. The reduction in material handling costs achieved is Rp 2,114,734.77 or around 81.84%, while the reduction in material handling distance reaches 306.85 meters or around 82.05%. Suggestions that can be used as considerations, it is expected that the company will apply the concept of national industry standards that aim to improve product quality.

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