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Proposed Improvement of Facility Layout to Optimize Material Handling Costs with ARC, AAD, ARD Approach at PT. Plating Services

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ABSTRACT: In the industrial world, the planning and layout of factory facilities is very important in realizing efficiency and smoothness in work. Improper layout can make material transfer time ineffective because the distance between stations is too far. PT. Plating services located in Cikarang have poor layout design and facilities where the distance of material handling from the incoming area to the production area and the temporary finish good area to the shipping area is too far to cause the value of Material Handling Costs (OMH) to be expensive. To reduce the value of OMH in the company, research activities were carried out with the approach of Activity Relationship Chart (ARC), Area Allocation Diagram (AAD) and Activity Relationship Diagram (ARD). The results showed that the long distance of material handling and carried out by 2 workers using hand pallet tools caused the cost of OMH to be expensive at Rp 11,647,584.-/month. Therefore, the researcher made a layout proposal to facilitate the movement of raw materials by adding Karakuri Conveyor facilities in the incoming area to production and quality control area to the shipping area. This can reduce the OMH value by 50.6%. Thus, PT. Plating services can improve the efficiency of the production process and optimize the survival or success of work in the long run.

KEYWORDS: Facility layout design, Material handling cost, ARC, AAD, ARD

I. INTRODUCTION

In the industrial world, the layout of factory facilities is very important and plays a very large role in achieving efficiency and smooth work. The physical design of a facility that pays attention to aspects of resources in the production of its products is called the facility layout [1]. Material handling system is one aspect related to the design and layout of the factory [2]. The main purpose of planning and arranging the layout of the plant is to create economical, safe, and comfortable work areas and production facilities for production operators so as to improve work morale and operator performance [2]. A good factory layout and planning can provide significant benefits in the production process. Therefore, planning and observation of factory layout is very important in the industrial world. Factory layout or facility layout can be interpreted as procedures for arranging physical factory facilities, to support smooth production activities. While according to another understanding, the layout of the factory is an arrangement of physical facilities (equipment, land, buildings, and otherfacilities). To know the layout design method, it is necessary to know the basic elements that need to be considered in plant design (plant design) whose scope is broader, which includes: financial planning, location determination and all designs needed to meet the physical needs of the company [3]. Poorly planned layout design between departments and poor material transfer distances can cause a number of problems such as decreased production and increased costs [3]. By redesigning the layout of the facility, it is expected that the production process will be smooth. As happened to the company PT. Plating Services, there are two areas that are quite far away and the frequency of workers is quite frequent. These activities include material handling from incoming to the production area and from the temporary finish goods area to the shipping area. Where the material loading distance from the place of incoming material to the production line is 10 meters and from the temporary area to shipping is 15 meters, the material transfer process is carried out using a hand pallet by 2 operators. By looking at the workload and the level of idle time intensity that is quite high, this is less effective and efficient for the continuity of the production process at PT. Plating Services. The goal to be achieved in this study is to make proposals for improving the layout and production facilities with an approach Activity Relationship Chart (ARC), Area Allocation Diagram (AAD) andActivity Relationship Diagram (ARD) to produce an effective and efficient material handling flow so as to reduce material handling costs (OMH).

II. RESEARCH METHOD

(Arif et al., 2023) in a research journal entitled "Perancangan Tata Letak Fasilitas Untuk Meminimalkan Jarak Material Handling Pada Pabrik Pupuk Organik PT. Petrokopindo Cipta Selaras Dengan Metode ARC Dan ARD". The research results showed that the crusher machine was placed too far away, resulting in the material transfer process occurring twice and making the production process

take longer. Therefore, the researchers proposed a layout to shorten the movement of raw materials by changing the location of the crusher machine next to the cooling machine. This results in a reduction in the distance traveled between production machines by 63%. Thus, the organic fertilizer factory PT. PCS can increase the efficiency of the production process and optimize the viability or success of work in the long term [4].

(Muslim et al., 2018) in a research journal entitled "Usulan Perbaikan Tata Letak Fasilitas Terhadap Optimalisasi Jarak dan Ongkos Material Handling dengan Pendekatan Sistematic Layout Planning (SLP) di PT Transplant Indonesia". The results of this research show that the material path distance on the production floor with the new layout has changed to 71.7 meters, with material handling costs per meter reduced from Rp. 1,105,954 to Rp. 712,402 or reduced by 35%. Based on the research results, the proposed layout is considered more effective and efficient because it can reduce material movement distances and reduce material handling costs on the production floor [5].

(Bukhori et al., 2023) in a research journal entitled "Analisis Pengaruh Variasi Sudut Kemiringan Feeder Terhadap Waktu Tempuh pada Alat Conveyor LowCost Energy (Karakuri) di PT Dharma Precision Parts". The research results stated that in terms of effectiveness, the use of karakuri conveyors resulted in a significant increase in box delivery travel time, reaching an 88.2% reduction in time at a 5° inclination angle. This shows that the karakuri conveyor design is effective in increasing productivity and reducing waiting time for materials at the work station [6].

As a result of studies from several research journal references, this research will use the ARC, AAD and ARD methods because they are simpler and are considered to be able to solve the problem of facility layout at PT. Coating service.

1. Layout

Layout is a process of designing and arranging the layout of physical facilities such as machinery or equipment, land, buildings, and space to optimize the relationship between workers, material flow, information flow and methods needed in order to achieve company goals efficiently, economically, and safely [9]. Factory layout can be defined as procedures for arranging factory facilities by utilizing the area optimally to support the smooth production process. Factory layout arrangement can improve production efficiency and effectiveness so that planned production capacity and quality can be achieved at the most economical cost level. Arranging factory layout is an activity related to designing the arrangement ofphysical elements of an activity and is always closely related to the manufacturing industry, and the drawing of design results is known as factory layout. For factories or companies must be evaluated layout.

2. Activity Relationship Chart (ARC)

Understanding the activity relationship chart (ARC) map according to Wignjosoebroto (2009) is a simple way or technique in planning the layout of facilities or departments based on the degree of activity relations which is often expressed in "qualitative" assessments and tends to be based on subjective considerations of each facility or department [12].

3. Area Allocation Diagram (AAD)

AAD is a continuation of ARC where in ARC is known the conclusion of the level of importance between activities. Thus, it means that some activities must be close to other activities and vice versa. Muther's Activity Relationship Diagram (ARD) approach is a depiction of ARD with line relationships that show the magnitude of the level of relationship between one activity and another activity. So it can be said that the relationship between activities affects the level of closeness between the layout of these activities. The proximity of the layout of the activity can be seen in Area Allocation Diagram (AAD) [8].

4. Activity Relationship Diagram (ARD)

According to Apple (1990), the Activity Linkage Diagram is depicted in the form of a bar diagram that shows the activity linkage approach, which shows each activity as a single activity model that does not emphasize the meaning of space at this stage of the planning process [13].

5. Material Handling Cost (OMH)

Material handling costs are costs incurred due to material activities from one machine to another or from one department to another whose amount is determined in a certain unit [7]. The unit is rupiah per meter of movement. Factors that affect the calculation of material handling costs are the tools used, the distance of transportation and the method of transportation.

Mileage measurements are adjusted to existing conditions in the field. Thus, if the mileage has been determined and the frequency of material handling has been taken into account, the cost of material handling can be known, where:

A. Material handling with human labor, using calculations:
OMH/m=Cost/d……(1)

B. Material handling with forklifts, using calculations:
Forklift Cost = (Purchase cost-Residual value)/ (Economicage)……(2)

So that the total cost of material handling is obtained:
OMH = f x OMH x r ..... (3)
Where:
f = Frequency (Number of material movements/day)
OMH/m= Material Handling Cost Per Meter
r = Distance between facilities/workstations
m = Meter
d = Seconds

This research was conducted at PT. Plating services begin with a literature study then continue with field observations of the initial layout then calculate material handling costs (OMH). The method used in research to solve layout and facility problems is the Activity Relationship Chart (ARC) method developed by Muther (1973) [14]. The flow of this research can be seen in the next picture.

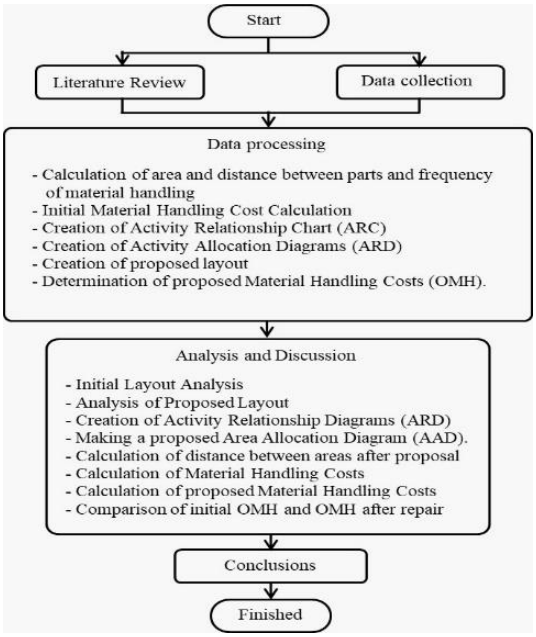

Fig. 1. Research framework

The research approach uses qualitative and quantitative approaches. The research variables used in the discussion of the problem are the distance of material handling and the frequency of material handling to reduce material handling costs. The data used in this study includes primary data between the initial layout, machine list, operation process map, flow process chart, while secondary data is obtained from the company in the form of information and images.

The data analysis method is carried out based on the results of field observations which include data on the initial layout of the production process and data on the results of measuring distances between machines and facilities in the production process, material flow diagram data and operation process map data. The data obtained from the results of the data collection is then calculated the cost of material handling from the place of incoming – production – finished goods – shipping. The layout data analysis stage was carried out using ARC, AAD, and ARD approaches to get a reduction in material handling costs.

III. RESULTS

PT. Plating Services is an electro plating service company for automotive components, as for the plating parts, namely rings, brackets, spindles, rotors and other types of vehicle spare parts.

Fig. 2. Product image

The initial state production layout consists of several interrelated work areas, for material movement using a hand pallet by 2 workers to supply to the production area, as an illustration of the layout of the production process and material flow in the company can be seen in the next picture.

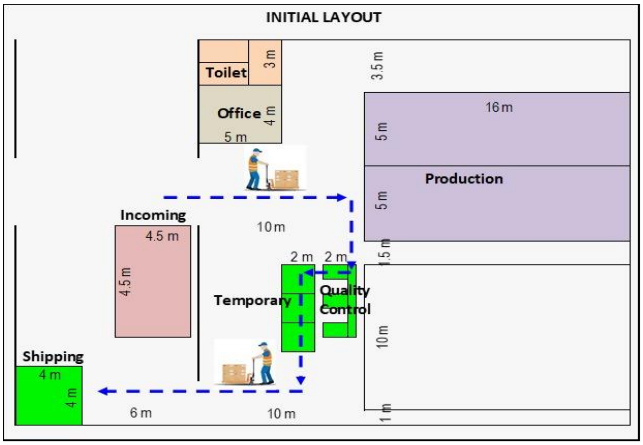

Fig. 3. Initial layout

Based on the picture above, there are 5 areas passed by materials during the plating process at the company, namely Incoming – Production – Visual inspection – Temporary area finished goods – Shipping area. The initial layout flow diagram can be seen in the image below.

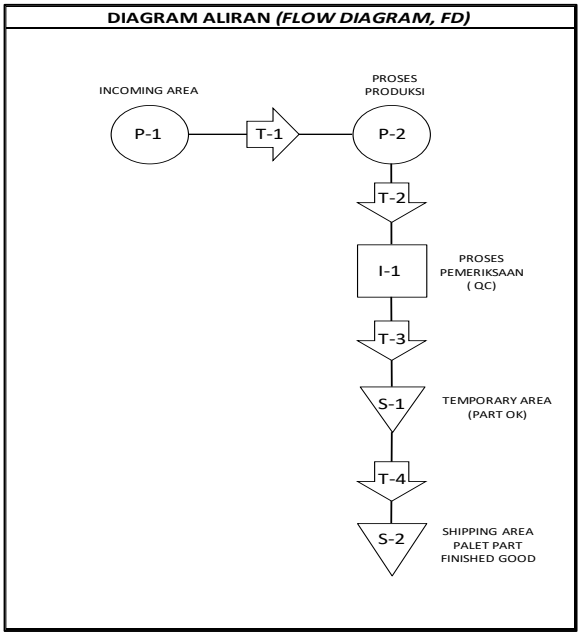

Fig. 4. Initial flow diagram

The cost of material handling per month can be known by data such as labor costs per month (due to material movement using hand pallet and human labor), the frequency of material handling, total workers, and the total distance of material handling. It is known that the monthly labor cost is Rp. 5,000,000.

In one day there are 7 working hours and there are 26 working days so that the material handling costs per month incurred by PT. Plating sservices amounted to Rp. 11,647,584 / month, then for material handling costs per meter of Rp. 1,224 / m obtained by dividing the total cost of material handling per month divided by the total distance of material handling.

Table 1. Initial material handling cost (OMH)

From	To	Component	Conveyance	Freq	Distance (meters)	Freq x Distance	OMH / meters	Total OMH
A	B	Incoming	Handlift	3	10	30	1.224	36.720
B	C	Production	Man	48	1	48	1.224	58.752
C	D	Quality Control	Man	144	1	144	1.224	176.256
D	E	Temporary area	Man	6	1	6	1.224	7.344
E	F	Shipping area	Handlift	6	23	138	1.224	168.912
						366	6.120	447.984

Activity Relationship Chart (ARC) is a map used to determine the relationship between each group of interrelated activities in a factory. In other words, the Activity Relationship Chart (ARC) is a map compiled to determine the level of relationship between activities that occur in each area with each other area in pairs. Basically, in a production process, there must be a relationship between an activity and other activities that are considered important and are always placed close together for the smooth running of the production process activities. The relationship is seen from the following aspects.

1. Departmental linkage
2. Material flow
3. Equipment used
4. Working man
5. Information and environment

In making ARC, several symbols are known that are often used as clues to close relations between departments, namely as follows.

Table. 2. Symbol activity relationship chart

The degree of closeness relationship in letter codes	
A	Absolute
E	Very Important
I	Important
O	Normal
U	Not Important
X	Not Expected

Based on the relationship of activities between departments contained in PT. Plating Services, then ARC for all available areas in the factory can be seen in the picture below.

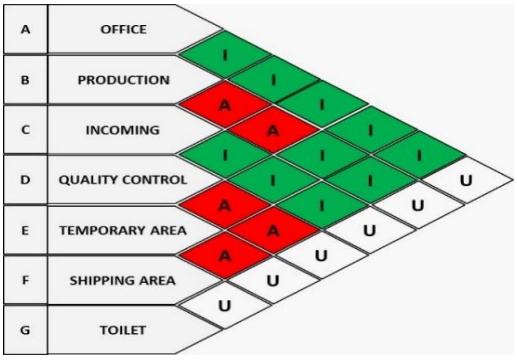

Fig. 5. Activity relationship chart (ARC)

Fig. 6. Area allocation diagram layout (AAD) from initial layout

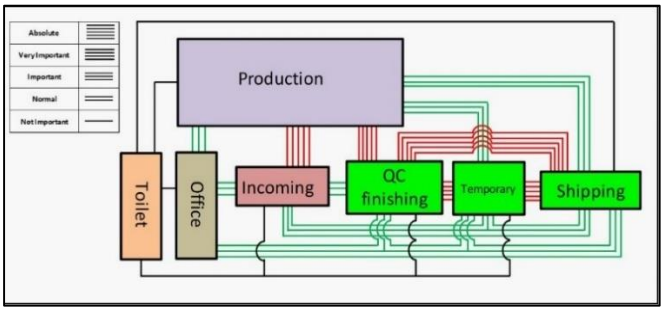

Fig. 7. Activity relationship diagram (ARD) from initial layout

From the ARC that has been compiled, it can be seen that the relationship that is absolutely necessary is the activity between departments A B C D E F. While the relationship that is considered very absolute is the relationship between departments B-C, B-D, D-E, D-F, and E-F. These five areas have a relationship that is felt to have high urgency because it relates to the flow of materials regarding the balance of the production line. The flow of this material must be maintained so that bottle necks do not arise in an area.

Proposed Layout Design

The proposed layout is based on the strongest level of relationship taking into account the cost factors for change and deployment to the workstation. By looking at the level of effectiveness and efficiency, the proposed improvement to reduce the cost of material handling (OMH) is to add karakuri kaizen / conveyor with a gravity system. Details on the implementation in the layout can be seen in the image below.

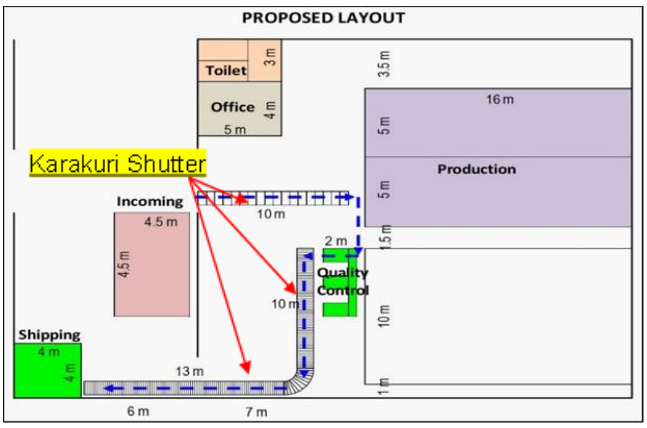

Fig. 8. Proposed layout

From the results of this proposed layout, benefits are obtained, namely material handling operators who were originally 2 people, so with this proposal material handling can be done with 1 person. The person's job is to supply materials from incoming to the production area with a karakuri conveyor and handle finished goods on the karakuri conveyor in the shipping area. The Karakuri conveyor can be seen in the picture below.

Fig. 9. Proposed conveyor karakuri

The cost of implementing this conveyor is only Rp. 12,500,000 with a return on investment of around 4 months. This is obtained from reducing the workforce by 1 person from 2 people for material handling. The conveyor does not use a motor for propulsion, it only uses gravity at an inclination angle of 5° and can run the box from top to bottom.

Activity Relationship Diagram (ARD) which is used as planning and analyzing the relationship of activity activities from a layout, then in this proposed layout obtained ARD as follows.

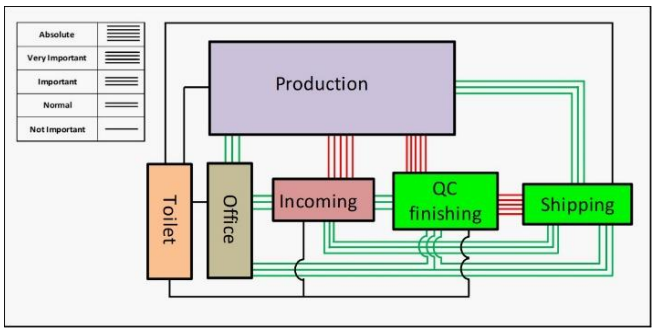

Fig. 10. Activity relationship diagram (ARD) from proposed layout

In accordance with the procedure and analysis steps, the ARD from this proposed layout is used to create an Area Allocation Diagram (AAD) with the following results.

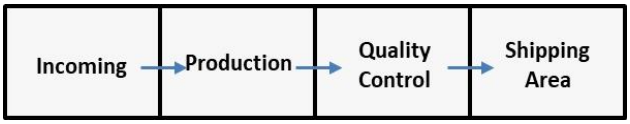

Fig. 11. Area allocation diagram (aad) from proposed layout

In the proposed layout there are changes to the flow diagram, these changes can be seen in the next image.

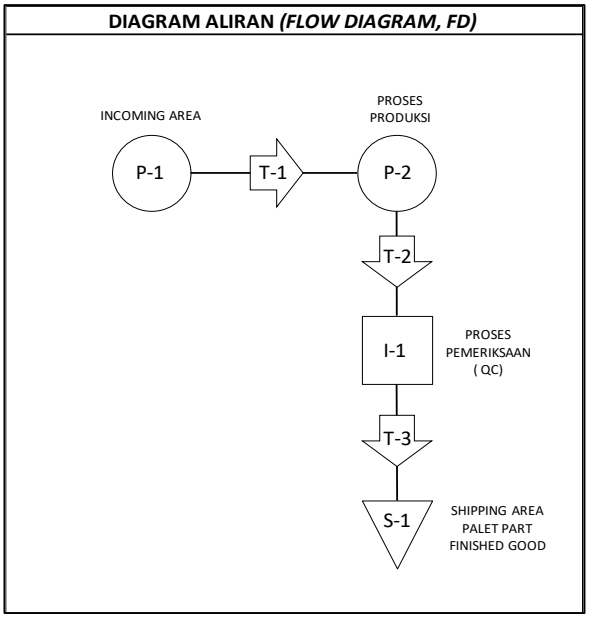

Fig. 12. Flow diagram layout after proposed

The next step is to calculate the distance between the areas that become the flow of the material according to the proposed layout. The distance is measured along the trajectory traversed by the material moving conveyor by drawing a line between the center of mass point of one department and the center of mass point of another department that has a material flow relationship.

Table. 3. Material transfer distance data between proposed areas

No	From	To	Distance (meter)
1	Incoming Materials (A)	Production (B)	10
2	Production (B)	Quality Control ('C)	1.5
3	Quality Control ('C)	Shipping (D)	23
From QC to Shipping it doesn't stop temporarily but transfers directly to shipping via conveyor			

After the distance between work acres is known, the next step is to calculate the material handling cost based on the length of the track between related activity areas, the frequency of material flow, the cost of material handling per meter, the amount of labor for material handling, then the total monthly material handling cost for the proposed layout is as follows.

Table. 4. Cost material handling (OMH) proposed

From	To	Component	Conveyance	Freq	Distance (meters)	Freq x Distance	OMH / meters	Total OMH
A	B	Incoming	Conveyer	3	10	30	605	18.150
B	C	Production	Man	48	1	48	605	29.040
C	D	Quality Control	Man	144	1	144	605	87.120
D	E	Temporary area	Man	6	1	6	605	3.630
E	F	Shipping area	Conveyor	6	23	138	605	83.490
					Total	366	3.025	221.430

The results of the OMH calculation from the proposed layout have been obtained so we can compare the initial OMH value with the proposed OMH value, can see the value of the decrease in OMH after improvement, and the efficiency obtained for the cost of OMH from the usual layout.

Table. 5. Efficiency value of OMH initial layout and proposed layout

	OMH Early	OMH End	Difference	Efisiensi
Day	447,984	221,430	226,554	50.6%
Month	11,647,584	5,757,180	5,890,404	

The table above is a comparison of OMH values in the initial layout and after the proposed layout. Where the OMH value in the initial layout was IDR 447,984, then we can see with the proposed layout and improvements getting an OMH value of IDR 221,430. The difference in the value of OMH from the initial layout with the proposed layout is Rp 226,554, so we can calculate the percentage of efficiency value from the results of the proposed improvement is 50.6%.

IV. CONCLUSION

Based on the calculation of material handling costs (OMH) after the proposed improvements, it can be concluded that adding a karakuri conveyor between the entry area and production area as well as the quality control area with the finish good delivery area can reduce OMH costs. amounting to 50.6%. Then another advantage obtained from this improvement is eliminating inventory in process in that area after quality control is carried out, the number of workers for material handling which was originally done by 2 people, so that with this proposed improvement it can be done with only 1 worker, material movement becomes it is easier, more effective and efficient to use the LowCost Energy Conveyor Equipment (Karakuri).

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