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Optimizing Material Handling Costs by Analysis of Facility Transfer Flow at PT XYZ

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Abstract: Poor facility layout design will cause losses for the company. PT. XYZ will redesign the layout of its company facilities to reduce material or raw material costs. This research aims to analyze material handling costs (OMH) using the production flow layout which is currently still being applied to activities in all factory lines, as well as analyzing the optimal flow sequence for each department at PT. XYZ. This research is also aimed at providing suggestions for a better flow layout with lower material handling costs (OMH) than the layout that the company is still implementing. In this research, various calculation efforts were used to achieve objectives such as From to Chart (FTC), Material Handling Costs (OMH), as well as Priority Scale Tables (TSP), ARC and ARD. From the research conducted, it was found that the flow of goods movement was optimal because all departments had the same coefficient. Based on the proposal given, Material Handling Costs (OMH) on the PT material transfer line. XYZ can be minimized by changing the layout of the goods movement flow from 5 factory departments from a straight type to a U-Shape type layout. If the proposed layout changes are implemented by PT. XYZ, then the company can minimize Material Handling Costs (OMH) by Rp. 12,240, from the previous cost of Rp. 53,550, to Rp. 41,310.

Keywords: Material handling costs, From to Chart, Priority Scale Table, Activity Relationship Chart, Activity Relationship Diagram

1. Introduction

Facility layout is one of the important things in achieving maximum efficiency in the manufacturing process. With a good layout and the right environment, the amount of production and employee performance will also increase. Therefore, to speed up the production process, efforts can be made to redesign the facility layout. Redesigning the layout of facilities must of course first identify the problems that exist in the company, such as observing the flow of employee movements [1].

Designing the layout of facilities is very necessary, because if the layout is not planned, both the position and distance of material movement, which is not optimal, will cause losses for the company, either a decrease in production results due to decreased productivity, or an increase in costs incurred [2]. The absence of queues accumulating in a process (bottleneck), the total cost of moving goods is minimal, and the absence of backflow (backtracking) from a company is a sign that the facility layout implemented is effective and efficient [3].

Material handling or moving goods is an activity that requires planning, controlling, monitoring and upgrading which requires costs and is a factor that influences the production cost structure, where the aim is to increase production capacity and improve material distribution [4]. Lack of planning for material handling in a company can hamper the production process which can have an impact on the company system [5]. The production activities of a factory/industry usually take place over a certain, fairly long period of time with a factory layout

that is fixed and does not change during that period, therefore errors or poor layout planning can cause significant losses for the company [3].

PT. XYZ is a manufacturing company engaged in paper production. This company processes paper from raw materials to final products, where material transfer is carried out from the beginning of receipt (input) to the end of storage (output). Production activities at PT. XYZ are carried out sequentially, with the production flow layout used in this company being a straight-line layout. Like the goals of many companies, productivity and minimizing costs are the targets of PT. XYZ. Therefore, PT. XYZ wants to move further with one effort, namely redesigning the layout of its company facilities to reduce the costs incurred for handling materials or raw materials for its production.

This research aims to analyze material handling costs (OMH) using the production flow layout that is currently still being implemented, as well as analyzing the optimal flow sequence for each department. This research is also aimed at providing suggestions for a better flow layout with lower material handling costs (OMH) than the layout that is still being implemented by the company.

2. Materials and Methods

In research at PT. In this XYZ, quantitative research methods are used, where quantitative research is a research method in which the data is obtained in the form of numbers and statements that have value and can be analyzed [6]. In this research, the data used is the distance between departments from the PT factory line. XYZ. The analysis carried out was to determine the optimal sequence of departments and analyze material handling costs (OMH) from the PT factory line. XYZ

The data used in this research is secondary data, and the data sources used were obtained from indirect observations and material assistance and discussions from other sources or research that have relevance to the problems discussed in this research. The quantitative data used in this research is the movement and distance of material transfer between departments and operational activities in PT's production flow. XYZ.

In this research, it was carried out in various stages starting from planning to creating articles from the research carried out. The flow of the research carried out can be seen in Figure 1.

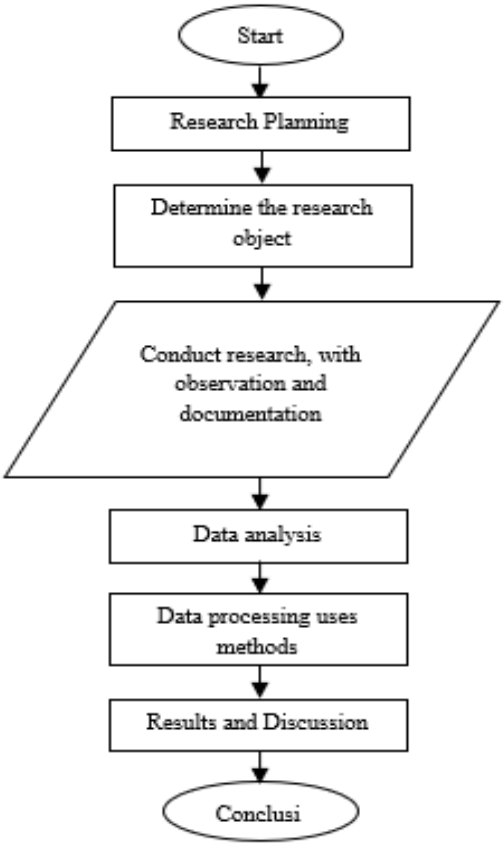

Figure 1: PT Research Flowchart. XYZ

Layout is defined as a procedure for arranging the facilities owned by a company to support the smooth running of the production process. The procedure used is used in conjunction with the area owned as a place for machines or basic facilities for production, movement and material storage activities, both temporarily and permanently. Layout definition is the arrangement of facilities or physical layout arrangements of a factory or company [3]. According to [7], facility design has several objectives, including:

1. Simplify all manufacturing activities
2. Minimize distance and costs of moving materials
3. Control the rotation of unfinished or semi-finished materials into finished materials as closely as possible
4. Minimize costs incurred for the capital equipment used
5. Effective use of labor with economical use of building space
6. Increase worker comfort and maximize worker safety

Layout affects the capacity of goods and movement of goods in a company. Determining the layout requires calculations to optimize the speed of the flow of goods moving sequentially. According to [8], the layout has 3 types, including:

1. Straight Line Layout

Straight line layout is the placement of each department that follows a straight-line pattern where there are two doors or paths located on two different sides as the incoming flow (input) and outflow (output) routes.

2. Layout of the Letter "U" (U-Shape Line)

The letter U layout or (U-Shape Line) is the placement of each department that follows the letter "U" pattern, with two different doors as input and output paths located on the same side.

3. Layout of the Letter "L" (L-Shape Line)

The letter L layout or (L-Shape Line) is the placement of each department that follows the letter "L" pattern, with two different doors as the incoming flow (input) and outgoing flow (output) which are located on the same side, but between the entrance and exit are relatively far apart.

Material handling is a system of activities which is a non-productive activity. It is called non-productive, because this activity does not change the shape and value of a material. The transfer of materials on a production line or throughout the company is an absolute thing and cannot be eliminated, therefore, efforts that companies can make are by minimizing costs or costs caused by the activity of moving goods/transportation, which is called hand off. Hand-off efforts can be carried out in various ways, including [3]:

1. Reducing the stages of transportation or moving materials
2. Minimize the distance of moving materials
3. Mechanizing transportation

According to [9], the measurement of material handling distance or material movement has various measurement systems that are adapted to the company's characteristics and needs. One method that can be used to measure the distance between goods moved in a company is Rectilinear Distance (Manhattan), which measures the distance that follows the path of parallel and perpendicular lines.

The material handling system is a large part of a manufacturing system, therefore, planning the movement of goods has a quite significant role in a company's manufacturing design. This is because material handling or goods moving activities cover more than half of production activities apart from operational activities such as assembly, packaging, etc. The material handling system assumes that materials that move are better than operators and machines that move towards materials on a company's production line [3].

Material Handling Costs (OMH) or goods handling costs are the movement or movement of all materials including raw materials, semi-finished materials, even to the final product. Optimizing material handling affects workforce ergonomics [10]. Material handling costs are incurred by the activity of moving materials from one department/machine to another department/machine in predetermined units. Transport equipment, method of transport, and distance of material movement are the main factors that influence material handling costs (OMH) [3].

According to [7], there are 5 benefits obtained from implementing and optimizing material handling, including:

1. Save costs
2. Save time
3. Streamline the production process

4. Increase production capacity
5. Improve worker safety

Material Handling Costs (OMH) or goods handling costs can be calculated by multiplying the total distance of the movement and the number (frequency) of the movement itself with the transportation (material handling) costs per meter [9]. Good material handling costs are material handling costs (OMH) or handling smaller materials. According to [6], the calculation of material handling costs (OMH) can be obtained using equation (1) below.

$$OMH/m = \frac{Operating\ costs/O'clock}{Transport\ distance/O'clock} \quad (1)$$

Material handling costs (OMH) are divided into several types, including material handling costs (OMH) for the salaries of material handling workers themselves which can be calculated using equation (2) as follows [7]:

$$OMH/m = \frac{Operator's\ salary\ per\ month}{Total\ Distance} \quad (2)$$

Meanwhile, material handling costs (OMH) for tools or machines supporting operational activities can be calculated using equation (3) below [7].

$$OMH/m = \frac{Tools\ cost\ per\ month}{Total\ distance} \quad (3)$$

In material handling or moving materials, the movement of this material can be done in all directions, both horizontally, vertically, and in curved paths. Material handling trajectories can be carried out in a constant or dynamic or changing trajectory [4].

From To Chart (FTC) is a table that describes two activity centers or two flow centers, inflow (inflow) and outflow (outflow) of a material handling which contains the distance or costs between these departments [2]. According to [2], From to Chart (FTC) inflow can be calculated using equation (4) below.

$$FTC\ Inflow = \frac{Machine\ costs}{Entrance\ fee\ from\ the\ machine} \quad (4)$$

Meanwhile, From to Chart (FTC) outflow can be calculated using equation (5) below.

$$FTC\ Outflow = \frac{Machine\ costs}{The\ cost\ comes\ out\ of\ the\ machine} \quad (5)$$

From To Chart (FTC) is used to regulate the movement of goods in large quantities, and it is necessary to organize or organize the optimum movement of goods based on the relationship between departments or workstations. By using From to Chart (FTC), companies can minimize the distance between processes or departments to minimize costs incurred. This can be achieved by analyzing, planning and measuring the company's production flow and knowing the dependencies between activities and between existing products [3].

The priority scale table (TSP) is a table that aims to show the order of departments or machines in a company's production flow or layout, which is arranged based on the priority scale of each department or machine. The main objectives of the priority scale table (TSP) include [2]:

1. Minimize costs incurred
2. Minimize the distance between handling/moving materials
3. Optimize the layout.

The priority scale table (TSP) is linked to the form to chart (FTC) for both FTC inflow and FTC outflow to determine the priority scale based on the priority coefficient of each department or machine.

A flow diagram is a type of operational process map that is used to describe the sequence of facilities or departments in a factory. This flow diagram is usually visualized as a production line layout for a factory/company [7].

Activity Relationship Chart (ARC) is one method used to measure the degree of closeness between departments or facilities. The relationship between activities or departments is influenced by many factors, such as the flow of information, the similarity of labor and tools, and the flow of raw materials [8]. By using the Activity Relationship Chart (ARC), you can determine the closeness of relationships between departments or activities that occur in the manufacturing system [1]. According to [9], the degree of relationship between departments or activities in a manufacturing system can be explained using the indicators shown in table 1.

Table 1: Indicators of Close Activity Relationship Chart (ARC)

Degree of Closeness	Description
A	Absolutely Close
B	It's Very Important To Be Close
I	It's Important To Be Close Together
O	It's Not A Problemo
U	No Need To Be Close Together
X	Don't Want To Be Close

According to [9], the reasons for determining the degree of closeness of the Activity Relationship Chart (ARC) between departments or activities can be seen in table 2.

Table 2: Reasons For the Closure of the Activity Relationship Chart (ARC)

Proximity Code	Reason
1	Work Flow Sequence
2	Worker Engagement
3	Supervision
4	Material And Employee Movement Flow
5	Information Flow
6	The Same Worker
7	Air Pollution, Noise And Unpleasant Odor

Activity Relationship Diagram (ARD) is a diagram that describes the relationship and degree of relationship between company areas or departments and material flows, where the proximity between facilities is visualized with codes, including lines, letters and certain colors. The code used to visualize the proximity between facilities is depicted in table 3 [9].

Table 3: Activity Relationship Diagram (ARD) Codes

Symbol	Line Code	Color Code	Proximity
A	4 lines	Red	Absolutely
E	3 lines	Orange	Very Important
I	2 lines	Green	Important
O	1 line	Blue	Not a problem
U	Without lines	Without color	No need
X	Wavy line	Brown	Undesirable

To make it easier to arrange the location of facilities, the Activity Relationship Diagram (ARD) is used as a way to determine priorities between facilities or departments that must be close together [7]. The aim of using the Activity Relationship Diagram (ARD) is to bring departments or facilities in the company closer together to minimize distance or material transfer, which is beneficial for the company to minimize costs or costs incurred [2]. An example of an Activity Relationship Diagram (ARD) layout that can be used can be seen in Figure 2.

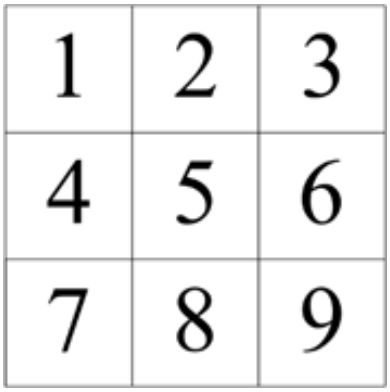

Figure 2: Layout of the 3x3 Activity Relationship Diagram (ARD)

3. Results & Discussion

In research at PT. XYZ obtained the data needed to calculate the material handling costs required, each cost has an influence on the size of the costs incurred for material handling. Vehicles used to move materials from one department to another at PT. XYZ is a vehicle in the form of a forklift, the details of material handling costs are presented in table IV:

Table 4: Details Of Material Handling Costs

Type of Cost	Information
Equipment purchases costs	Rp425.000.000/12 years of economic life
Operator salary	Rp2.500.000
Maintenance Cost	Rp1.800.000
BBM Cost	Rp3.000.000
Tool mileage/O'clock	350 meters
Working hours	8 o'clock/day
Working days	24 day/month

The details in table I are used to calculate material handling costs. Material handling costs are calculated by comparing the total costs incurred (maintenance costs, fuel, etc.) with the distance traveled in similar units. The calculations carried out can use equation (6) below.

$$Total\ cost\ = Tool\ price + Cost\ O\&M \quad (6)$$

Depreciation of a Forklift with an Economic Life of 12 Years. Equipment depreciation is the depreciation or decrease in the price or selling value of an asset or machine, in this case a forklift, per year.

$$Dep = \frac{Rp.425.000.000}{8\ O'clock \times 24\ Days \times 12 Month \times 12\ Years} = Rp15.372\ /O'clock$$

Operator salary is the cost that the company pays to workers, especially machine and tool operators, which are given monthly. In this research, operator salaries are converted into hourly wages.

$$Operator\ salary = \frac{Rp.2.500.000}{8\ O'clock \times 24\ Days} = Rp13.021\ /O'clock$$

Maintenance costs or maintenance costs are costs allocated to maintain the equipment used so that it continues to work in optimal performance and condition.

$$Maintenance = \frac{Rp.1.800.000}{8\ O'clock \times 24\ Days} = Rp9.375\ /O'clock$$

The fuel cost allocation is still in effect because equipment in the form of forklifts still uses fuel oil in the form of fossil fuels of the diesel type to operate.

$$Cost\ BBM = \frac{Rp.3.000.000}{8\ O'clock \times 24\ Days} = Rp15.625\ /O'clock$$

All costs incurred are obtained from the accumulation of existing costs, namely operator salaries, maintenance or upkeep costs, and fuel oil (BBM) costs, which the company must incur so that all activities in the company continue to run well.

$$Total\ Cost = 15.372 + 13.021 + 9.375 + 15.625$$
$$Total\ Cost = Rp53.393\ /O'clock$$

OMH is a cost that must be incurred by the company to meet the needs of the process of moving goods between departments in units of IDR/meter. Material handling costs (OMH), will be influenced by the distance between departments as well as the frequency of movement or movement of materials on the production line from the initial arrival of raw materials to the finished product.

$$OMH = \frac{Rp.53.393}{350\ meters} = Rp153\ /meters$$

In research at PT. XYZ knows that the layout used by the company is straight or straight lines. Material transfer at PT. XYZ is carried out using tools or machines in the form of forklifts which are used from the receiving department (input) to the storage department (warehouse). Details of the material handling line flow can be seen in Figure 3.

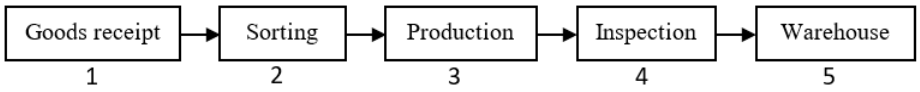

Figure 3: Flow of goods movement between PT departments. XYZ

Before determining the OMH between departments, the distance between departments must first be calculated to determine the costs incurred for each department. Distance between departments at PT. XYZ is displayed in table 5.

Table 5: Distance Between Departments

Home Department	Destination Department	Distance (m)
Reception	Sorting	80
Sorting	Production	50
Production	Inspection	70
Inspection	Warehouse	150
Total Distance		350

Based on Material Handling Costs (OMH) per meter and distance between PT departments. XYZ is known, then Material Handling Costs (OMH) between departments at PT can be obtained. XYZ is as follows:

1. OMH Receptions departement → Sorting (1 → 2)
$$OMH(1 \rightarrow 2) = 153\ \times 80 = Rp12.240$$
2. OMH Sorting departement → Production (2 → 3)
$$OMH(2 \rightarrow 3) = 153\ \times 50 = Rp7.650$$
3. OMH Production departement → Inspections (3 → 4)
$$OMH(3 \rightarrow 4) = 153\ \times 70 = Rp10.710$$

4. OMH Inspections Departement → Warehouse (4 → 5)

$$OMH(4 \rightarrow 5) = 153 \times 150 = Rp22.950$$

5. Total OMH All departement

$$\Delta OMH = OMH\ beginning - OMH\ end \quad (7)$$

$$OMH(1,2,3,4,5) = 12.240 + 7.650 + 10.710 + 22.950$$

$$OMH(1,2,3,4,5) = Rp.53.550\ /O'clock$$

From Material Handling Costs (OMH) between PT factory departments. XYZ that has been obtained, the priority scale can be calculated for each department. To help determine the priority scale of departments at the PT factory. XYZ, the From to Chart (FTC) table can be used which is depicted in table 6.

Table 6: Distance Between Departments

From/To	1	2	3	4	5	Total
1		12.440	-	-	-	12.440
2	-		7.650	-	-	7.650
3	-	-		10.710	-	10.710
4	-	-	-		22.950	22.950
5	-	-	-	-		0
Total	0	12.440	7.650	10.710	22.950	53.750

From the From to Chart (FTC) that has been obtained, inflow and outflow calculations can be carried out for each department at the PT factory. XYZ. The results of the From to Chart (FTC) inflow table calculation can be seen in table 7.

Table 7: Departmental Inflow Table

From/To	1	2	3	4	5
1		1	-	-	-
2	-		1	-	-
3	-	-		1	-
4	-	-	-		1
5	-	-	-	-	

Meanwhile, the results of the calculation of the From to Chart (FTC) outflow table between PT departments. XYZ can be seen in table 8.

Table 8: Departmental Outflow Table

From/To	1	2	3	4	5
1		1	-	-	-
2	-		1	-	-
3	-	-		1	-
4	-	-	-		1
5	-	-	-	-	

From tables 7 and 8, the coefficients of both inflow and outflow in each PT department. XYZ has the same value, meaning that a priority scale table can be obtained as in table 9.

Table 9: Priority Scale Table

Priority					
From/To	**1**	**2**	**3**	**4**	**5**
1	2				
2	3				
3	4				
4	5				
5					

From Table 9, it is known that the flow of material movement between PT departments. XYZ is already in an efficient condition and optimal sequence.

In this research, apart from using a priority scale table (TSP), the closeness between departments is also described using the Activity Relationship Chart (ARC) to determine the best layout for each department. Activity Relationship Chart (ARC) between PT departments. XYZ can be seen in Figure 6.

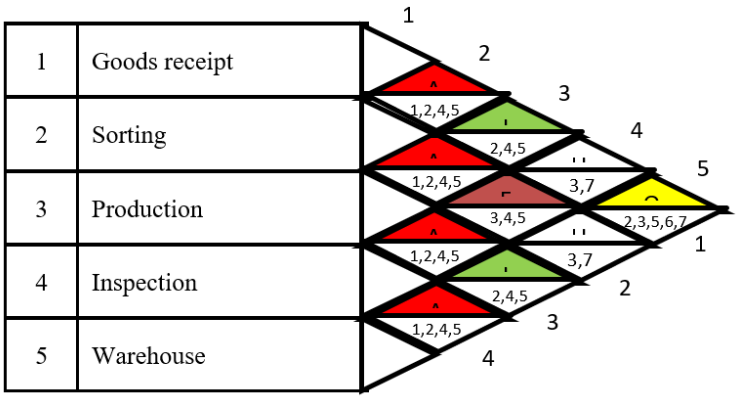

Figure 6: Activity Relationship Chart (ARC) PT Department. XYZ

PT. XYZ uses a straight layout between departments. In this research, PT. XYZ proposed to change the layout of its material transfer line to a U-Shape layout. This change in layout is an effort to reduce material handling costs (OMH) by reducing the distance between departments. The proposed layout that can be used is shown in Figure 7.

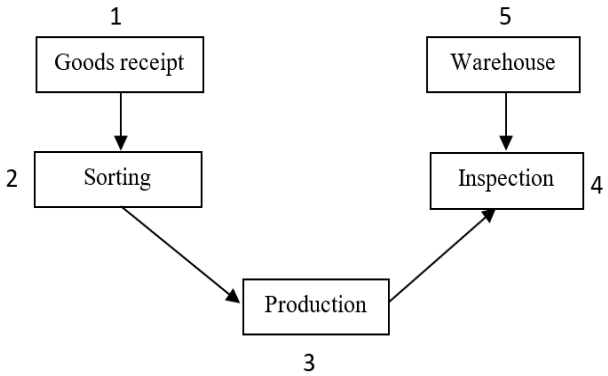

Figure 7: Proposed flow of goods movement between PT. XYZ departments

Before determining the proposed OMH between departments, the distance between new departments must first be calculated to determine the costs incurred. The proposed layout distance between departments at PT. XYZ is displayed in table 10.

Table 10: Proposed Distance Between Departments

Home Department	Destinations Department	Distance (m)
Receptions	Sorting	55
Sorting	Production	40
Production	Inspection	60
Inspection	warehouse	115
Total distance		270

Based on the proposed Material Handling Costs (OMH) per hour and distance between PT departments. XYZ is known, then we can obtain the proposed inter-departmental Material Handling Costs (OMH) for the factory at PT. XYZ is as follows:

1. OMH Receptions Departement → Sorting (1 → 2)

$$OMH(1 \rightarrow 2) = 153 \times 55 = Rp8.415$$

2. OMH Sorting Departement → Production (2 → 3)

$$OMH(2 \rightarrow 3) = 153 \times 40 = Rp6.120$$

3. OMH Productions Departement → Inspections (3 → 4)

$$OMH(3 \rightarrow 4) = 153 \times 60 = Rp9.180$$

4. OMH Inspections Departement → Warehouse (4 → 5)

$$OMH(4 \rightarrow 5) = 153 \times 115 = Rp17.595$$

5. Total OMH All Departement

$$OMH(1,2,3,4,5) = 8.415 + 6.120 + 9.180 + 17.595$$
$$OMH(1,2,3,4,5) = Rp.41.310\ /O'clock$$

6. OMH Difference before and after proposal *U-Shape*

$$\Delta OMH = OMH\ Beginning - OMH\ End \quad (7)$$
$$Diffrence\ OMH = Rp53.550 - Rp41.310$$
$$Diffrence\ OMH = Rp.12.240\ /O'clock$$

Based on the Priority Scale Table (TSP) and Activity Relationship Chart (ARC) which are known for the coefficients and proximity of each department, an Activity Relationship Diagram (ARD) can be created to visualize the closeness layout between PT departments. XYZ. The proposed Activity Relationship Diagram (ARD) layout used is ARD 2x3 with the same coefficient of closeness between departments, namely 1, ARD can be created for the five departments in PT. XYZ is in a U-Shape type layout which can be seen in Figure 8.

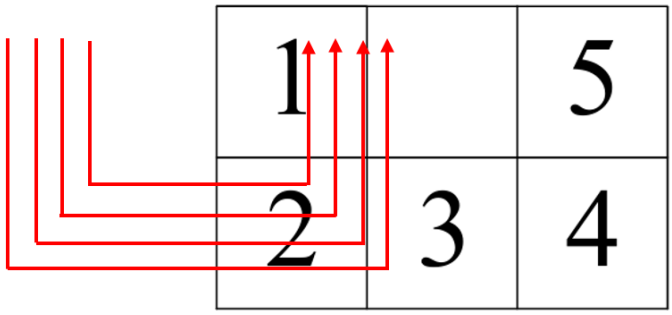

Figure 8: Activity Relationship Diagram (ARD) between PT XYZ departments

4. Conclusion

Designing the layout of facilities is very necessary, because if the layout is not planned, both the position and distance of moving materials which are not optimal, it will cause losses for the company, either a decrease in

production results due to decreased productivity, or an increase in costs incurred. One of the characteristics of a good layout is optimal material handling in a company, because a company's lack of planning for material handling can hamper the production process which can have an impact on the company system.

Based on the research conducted, by utilizing the From to Chart (FTC) table for both inflow and outflow, as well as using the Priority Scale Table (TSP), Activity Relationship Chart (ARC) and Activity Relationship Diagram (ARD), it is known that the material transfer flow of PT. XYZ is optimal because all departments have the same coefficient and degree of closeness. Based on the proposal given, Material Handling Costs (OMH) on the PT material transfer line. XYZ can be minimized by changing the layout of the goods movement flow from a straight type to a U-Shape type layout. This change can minimize Material Handling Costs (OMH) of Rp. 12,240 from the previous Rp. 53,550, to Rp. 41,310.

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