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Facility Layout Design using CORELAP and ALDEP Algorithm with Flexsim Simulation

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Abstract:

The material transfer system is one of the things that influenced the efficiency of the layout of a production floor. The role of the machine arrangement and equipment in a workshop is very important for productivity in production activities. The methods CORELAP (Computerized Relationship Layout Planning) and ALDEP (Automated Layout Design Program) can improve the layout of production facilities. This is indicated by a decrease in the displacement moment which has an impact on the efficiency of the displacement distance. Furthermore, simulation of flexsim is used to find the productivity level of each facility improvement method that is used. The level of productivity, in this case, is indicated by the number ofgoods from raw materials to finished products.

Keywords **—Facility Layout, CORELAP, ALDEP, Flexsim.**

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I. INTRODUCTION

Manufacturing is the process of converting raw materials, components, or parts into a final product that meets consumer expectation or specification and has a higher selling value for profit. The role of the arrangement of machines and equipment in a workshop is very influential on production activities, especially for the time used in the production process. The production process with machine conditions and production flow that is unorganised will cause high material transfer. A good layout always involves the procedure of moving materials in the factory [1]. The purpose of facility design is to bring inputs (raw materials) through each facility in the shortest possible time, at a reasonable cost [1]. A good layout will provide great benefits for the company to simplify the manufacturing process, minimize the movement of goods, maintain flexibility, maintain high rotation of semi-finished goods, reduce investment in equipment, save building space usage, increase the ability to use labour, and provide convenience, safety and comfort for employees

One method that can be used to improve the layout is by using CORELAP (Computerized Relationship Layout Planning) algorithm, ALDEP (Automated Layout Design Program) algorithm, and productivity evaluation using Flexsim software. ALDEP is a constructionbased algorithm and is used when an activity relationship is a major consideration. It develops a layout design by randomly selecting a department and placing it in the layout. The departments are placed in a layout based on their closeness rating [2]. The CORELAP method can be used to make improvements to the layout of the facility, by minimizing the distance moved and processing time. And the 5S method can

be used as an attitude of the company's work to create a better working environment [3].

II. METHODOLOGY

Plant layout is planning the path each component/part of the product is to follow through the plant, coordinating the paths of the various parts so that the manufacturing processes may be carried out in the most economical manner, then preparing drawing or other representation of the arrangement and finally seeing that the plan is properly put into effect [1].

A. ALDEP Algorithm

Steps on the ALDEP algorithm is as follows:

1. ALDEP will choose a random facility that is the closest to each other, which is A or E and place it in the upper left corner of the layout.
2. The selection of the next facility is based on the highest proximity or the same as the first facility which is selected randomly.
3. The next selection is carried out at a lower connection-level than A or E, namely I.
4. The total score for the resulting alternative is obtained by adding up each score from the adjoining facility.

B. CORELAP Algorithm

CORELAP is a construction algorithm, where the layout arrangement is based on the calculation of Total Closeness Rating (TCR) from each department. TCR is the number of close connections obtained from the Activity Relationship Chart (ARC). The calculation stages in the CORELAP method is as follows:

1. Calculate the TCR for each department.
2. Place the department with the highest TCR value TCR at the centre of the layout.
3. The next department that is chosen to be placed in the layout is the department with connection A. Next is the placement of the department with connection-level E, I, and so on.
4. Placement is based on the amount of weight between the departments that have entered and those who will enter.
5. Evaluation of the layout is through the layout score.

C. Flexsim Simulation

Simulation using flexsim software is a type of simulation program that can provide an overview of the distance, time with the desired production target. [4]. The use of a computer simulation tool allows to predict the work of the production line and provide some of the behaviour of systems [5]. Software named Flexsim, which can module and simulate an industrial logistics system performance in extremely condition, such as warehouse extremely layout, high rate dispatching, huge number of orders, complex logistics operation condition[6].

Flexsimis a PC-Based software that is used to model, simulate, and visualize the processes of business. Flexsim can help to determine factory capacity, balance manufacturing lines, manage the cause of delay, solve inventory and in-process inventory problems, test a new scheduling practice, optimize the production rates and adjust spending. Each Flexsim model can be depicted in 3D virtual reality animation. In Addition, Flexsim allows modellers with model and submodelprogramming capabilities directly in C++.

III. RESULT

The application of CORELAP, ALDEP, and Flexsim simulation methods is done on PT Taka Precision Manufacturing (PT TPM). PT TPM needs a method to redesign the facility layout that can reduce the moment of material transfer on the production floor and reduce the total cost of moving materials. The layout of the factory is designed based on the process of latching products which has 80% of the demand from the total demand for the product produced. Material handling owned is overhead cranes, chain blocks, forklifts hand lifts, and hand pallets.

Figure 1. Latching Product

The stages for the layout improvement process can be explained as follows:

A. Initial Distance Calculation

Calculation of distance between workstations using *rectilinear* distance calculation [7].

$$d_{ij} = |x_i - x_j| + |y_i - y_j| \quad (2)$$

TABLE I
RECAPITULATION OF INITIAL DISTANCE CALCULATION

No	From	To	X (m)	Y (m)	Total (m)
1	Receiving	Lathe	19,044	8,722	27,726
2		Wire cut	1,411	16,632	18,043
3	Lathe	Assembling	1,873	10,081	11,954
4		CNC	3,279	13,579	16,858
5	Wire cut	Assembling	18,541	17,99	36,531
6	CNC	Assembling	5,153	3,499	8,652
7	Assembling	Mechanic Area	17,13	14,092	31,222
				Total	150,986

B. Frequency calculation and Initial Transfer Moment

Transfer moment is a value that is used as a comparison for the layout of the improvement that will be designed. The result of the calculation of the frequency and the initial transfer moment can be seen in Table 2.

TABLE II
FREQUENCY AND INITIAL DISPLACEMENT MOMENT

No	From	To	Frequency	Y (m)	Total (m)
1	Receiving	Lathe	7	27,726	194,082
2		Wire cut	1	18,043	18,043
3	Lathe	Assembling	6	11,954	71,724
4		CNC	1	16,858	16,858
5	Wire cut	Assembling	1	36,531	36,531
6	CNC	Assembling	1	8,652	8,652
7	Assembling	Mechanic Area	1	31,222	31,222
	Total				377,112

C. Making Activity Relationship Chart Table

Activity relationship chart (ARC), is obtained from interview results with the company. ARC can be seen in Table 3.

TABLE III
ACTIVITY RELATIONSHIP CHART (ARC)

Facility	No	Relationship											Luas (m^2)
M. Area	1	-	U	E	U	U	I	U	U	O	E	U	126,000
Maint.	2		-	U	E	O	O	O	U	U	U	U	42,000
Welding	3			-	E	U	U	U	U	U	U	E	40,000
M.Handling	4				-	I	O	E	U	U	U	A	22,000
CNC	5					-	E	A	O	I	U	E	18,750
Milling	6						-	E	U	U	U	O	13,500
Lathe	7							-	U	U	I	A	13,500
Line Bor	8								-	E	U	U	18,000
Balancing	9									-	U	U	10,000
Wire Cut	10										-	E	11,000
Assembling	11											-	22,000

D. Framing ALDEP Algorithm Layout

Framing layout with ALDEP algorithm requires inputs such as length, width, number of departments, number of iteration on the software and the degree of proximity between one department and other departments on the production floor. Furthermore, in running the ALDEP software, automatic search is used which will produce an optimum layout with the greatest layout efficiency value.

Based on the best alternative, the distance between departments is calculated. The results of the ALDEP algorithm layout can be seen in Figure 2.

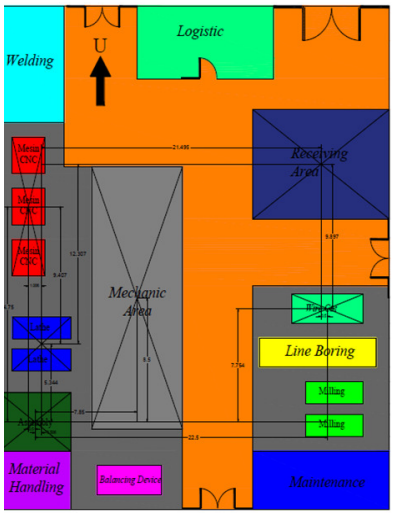

Fig. 2 ALDEP layout result

The results of the calculation of the displacement distance of the proposed ALDEP layout can be seen at Table 4.

TABLE IV
RECAPITULATION OF THE CALCULATION OF THE PROPOSED DISTANCE FROM ALDEP

No	From	To	X (m)	Y (m)	Total (m)
1	Receiving	Lathe	21,495	12,307	33,802
2		Wire cut	0,5	9,897	10,397
3	Lathe	Assembling	0,506	5,344	5,85
4		CNC	1,006	9,407	10,413
5	Wire cut	Assembling	22,5	7,754	30,254
6	CNC	Assembling	0,5	14,75	15,25
7	Assembling	Mechanic Area	7,85	8,5	16,35
				Total	122,16

The calculation of the displacement moment of the proposed ALDEP layout can be seen in Table 5.

TABLE V
FREQUENCYAND DISPLACEMENT MOMENT IN ALDEP METHOD

No	From	To	Frequency	Y (m)	Total (m)
1	Receiving	Lathe	7	33,802	236,614
2		Wire cut	1	10,397	10,397
3	Lathe	Assembling	6	5,85	35,1
4		CNC	1	10,413	10,413
5	Wire cut	Assembling	1	30,254	30,254
6	CNC	Assembling	1	15,25	15,25
7	Assembling	Mechanic Area	1	16,35	16,35
		Total			354,378

The calculation of the layout efficiency can be calculated in the following way.

$$E = 1 - \frac{354{,}378 - 377{,}112}{377{,}112} \times 100 \quad = 7{,}028\ \%$$

E. Penyusunan Layout Algoritma CORELAP

The layout arrangement using the CORELAP algorithm is carried out by calculating the number of closeness expressed by the Total Closeness Rating (TCR) as the basis for calculating the placement of workstations. By entering the machine name data, the size and area of the production floor, and the degree of proximity, the results of the CORELAP algorithm layout are obtained in Figure 3.

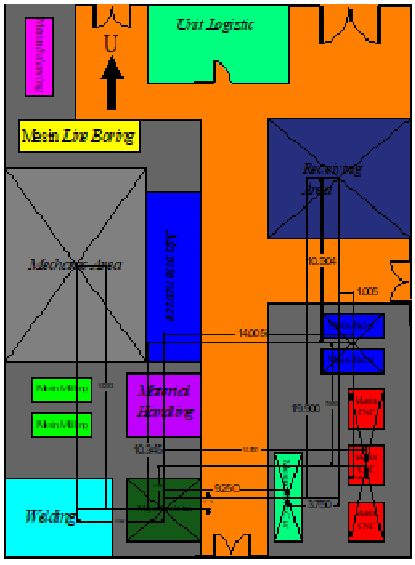

Fig. 3 CORELAP Layout result

The calculation result of distance of the proposed displacement layout using CORELAP layout can be seen in table 6.

TABLE VI
RECAPITULATION OF CORELAP PROPOSED DISTANCE CALCULATION

No	From	To	X (m)	Y (m)	Total (m)
1	Receiving	Lathe	1,005	10,304	11,309
2		Wire cut	3,75	19,9	23,65

3	Lathe	Assembling	10,345	14,005	24,35
4		CNC	0,994	7,595	8,589
5	Wire cut	Assembling	9,25	0,75	10
6	CNC	Assembling	15	2,75	17,75
7	Assembling	Mechanic Area	6,437	15,253	21,69
				Total	117,338

The moment of shifting the layout of the proposed CORELAP can be seen in Table 7.

TABLE VII
FREQUENCY AND MOMENT OF DISPLACEMENT CORELAP METHOD

No	From	To	Frequency	Y (m)	Total (m)
1	Receiving	Lathe	7	11,309	79,163
2		Wire cut	1	23,65	23,65
3	Lathe	Assembling	6	24,35	146,1
4		CNC	1	8,589	8,589
5	Wire cut	Assembling	1	10	10
6	CNC	Assembling	1	17,75	17,75
7	Assembling	Mechanic Area	1	21,69	21,69
	Total				306,942

The efficiency value of the layout is

$$E = 1 - \frac{306{,}942 - 377{,}112}{377{,}112} \times 100 = 19{,}607\ \%$$

F. Layout Simulation Using Flexsim Software

Layout simulation using Flexsim software can provide an overview of the level of productivity on a predetermined layout. Flexsim software simulation from the Automated Layout Design Program algorithm obtained the results of the material transfer process using six production facilities, namely Receiving Area, Lathe, CNC Machine, Wire Cut Machine, Assembly Table, and Mechanic Area. The result of flexsim simulation and the level of of productivity of the layout simulation can be seen in figure 4 and 5

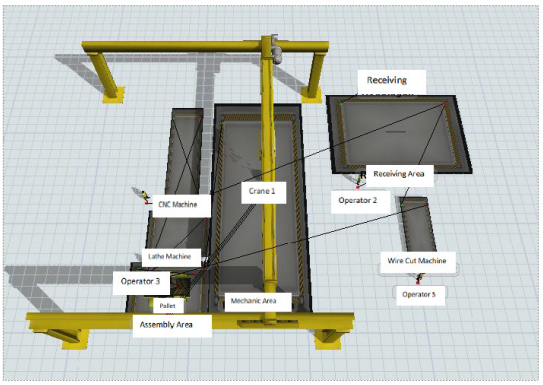

Fig. 4Flexsim Simulation Layout ALDEP Algorithm

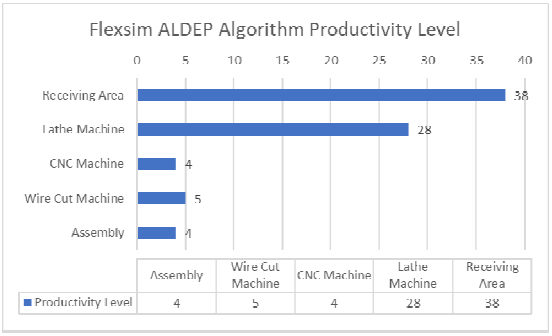

Fig. 5 Grafik Tingkat ProduktivitasFlexsimAlgoritma ALDEP

The Flexsim simulation results from the proposed ALDEP layout show that the productivity level is 79 parts/hour with the number of shifting goods from raw materials to finished products are 4 units/hour. The result of moving finished products per hour is obtained from the productivity level of the Assembly Desk because every product that has passed the Assembly Table has already been produced and assembled and then placed in the Mechanic Area. The Mechanic Area's productivity is equal to zero because the Mechanic Area facility does not distribute parts to other facilities.

The layout of flexsim simulation and the level of productivity based on the CORELAP algorithm can be seen in Figure 6 and 7.

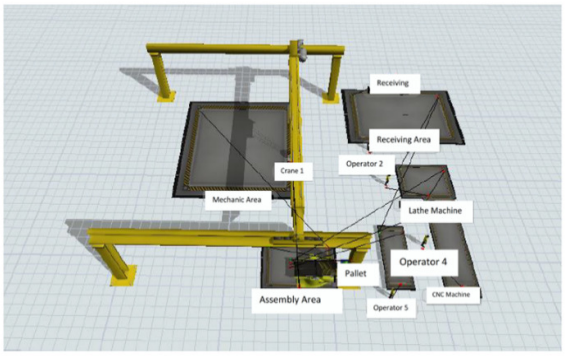

Fig. 6Flexsim Simulation Layout CORELAP Algorithm

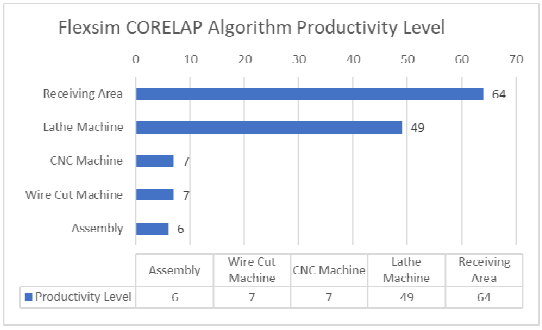

Fig. 7Flexsim Productivity Level Graph CORELAP Algorithm

The results of the Flexsim simulation with layouts using the CORELAP method obtained a productivity value of 133 parts/hour with the number of shifting goods from raw materials to finished products which are 6 units/hour.

IV. CONCLUSIONS

The problem that occurred in the initial layout was the accumulation of facilities in the workshop area which resulted in displacement moment of 377,112m/unit. In order to solve that problem, the ALDEP algorithm and the CORELAP algorithm will be used. The result of the proposed use of the two algorithms shows that there is no more accumulation of facilities in the workshop area. Improvements are also shown by the decrease in the displacement moment on the proposed layout of the ALDEP algorithm, which is 354,378m/unit, and the displacement moment in the proposed layout of the CORELAP algorithm which becomes 307,942 m/unit.

Improvement can also be seen from the increase in the layout efficiency and increase productivity in the layout which resulted from the use of these two algorithms. Flexsim simulation shows that the layout result from the use of the ALDEP algorithm has a layout efficiency value of7,028% with a productivity level of 79 parts/hour, while by using CORELAP algorithm, the layout efficiency value that is obtained is 19,607% with a productivity level of 133 parts/hour. Based on the layout efficiency value and the productivity level, the proposed layout resulting from the use of CORELAP algorithm is chosen because it has a maximum value that results in a reduction of the displacement distance of 69,17 m/unit.

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