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Design and improvement layout of a production floor using automated layout design program (ALDEP) and CRAFT algorithm at CV. Aji Jaya Mandiri

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Abstract. Different computerized algorithms are used to assist the layout planner in generating alternate layout. CRAFT (Computerized Relative Allocation of Facilities Technique) has been developed to improve an existing layout, while ALDEP (Automated Layout Design Program) is a construction layout. The improvement given by ALDEP over CRAFT technique was found to reduce annual material handling cost by 23% [1]. This study hypothesize that better result could be gained by combined two algorithms rather than their independent application. The hypothesis is verified by taking layout problems of CV Aji Jaya Mandiri. The objective of the study is to get the optimal layout of CV Aji Jaya Mandiri using ALDEP and followed by improving it with CRAFT. ALDEP based on the value of proximity (total closeness rating). The layout resulted from ALDEP is improved by exchanging machines positions. The newly layout obtained by ALDEP is compared with the result layout improved by CRAFT. There are two criteria for comparing the layout: material handling cost taken from MHES (material handling evaluation sheet), and the manufacturing lead time or processing time using Promodel simulation. The material handling cost of the layout resulted by CRAFT was decreased by 6,24%, that is mean that CRAFT was improved the layout effectively. The result of simulation showed the manufacturing lead time of the improved layout decreased 23 minutes. Layout evaluation using Adjacency Based Scoring for the CRAFT layout increase 15% compare with the initial layout so it was selected as the best layout. This study concluded that combined use of computerized layout design algorithms provides better result,

Keywords: ALDEP, CRAFT, Facility layout Design, ProModel, Simulation

1. Introduction

Facility layout design is the field of selecting the most effective arrangement of physical facilities to allow the greater efficiency. It reduces the total cost of manufacturing activity provides optimum space to give maximum output. The plant layout or facilities layout can be defined as an arrangement of the factory facilities to support the smooth running of the production process. These settings will increase the utilization of the area for the placement of the machinery or other production support facilities, smooth movement transfer of material, material storage which is either temporary or permanent, operator and so on other personnel. Setting a good and planned layout will determine the efficiency of the production process. According to [2] a good layout will give more output although the cost is the same or less, less man hours, and or machine hours.



2. Method

The hypothesis is developing a new layout using construction routine followed by improvement routine is more fruitful than constructing new layout with a construction routine alone or improving a working existing layout using improved routine [1]. The hypothesis is verified by taking CV Aji Jaya Mandiri layout problems. The initial layout of production floor of the CV Aji Jaya Mandiri was not well-ordered. The flows of material are not efficient. The first step evaluated of current layout using adjacency based scoring. The optimal layout of CV Aji Jaya Mandiri was obtained using ALDEP and followed by improving it with CRAFT. Data collection for designing layout, such as the initial layout, characteristic of the product, operation process chart (OPC), standard times, capacities and size of machines. These data was processed to develop routing sheet, material handling planning sheet (MHPS), from to chart, total closeness rating, and material handling evaluation sheet.

The first method used to design the layout of the production floor is ALDEP (Automated Layout Design Program). This method is one of many construction algorithms for designing layout. The use of ALDEP method is expected to make a better layout proposal. After getting the results of ALDEP layout then calculate material handling cost based on material handling evaluation sheet (MHES). The proposed layout was improved by CRAFT and compare the cost of material handling of improved layout than the previous layout. Next, running a simulation to obtain the processing time of the proposed layout by ALDEP and the improved layout as well, which further evaluated the optimal layout using Adjacency Based Scoring to make sure the optimal layout the better layout.

3. Result and Discussion

The important things in facility layout design is reducing cost by maximizing adjacency of highly interacting components of a system or reducing material handling cost or distance between work stations. The first step is to evaluate the initial layout CV. Aji Jaya Mandiri using Adjacency Based Scoring method resulted the value of the relationship of proximity calculation. The priority scale is from FTC (from to chart) and MHPS (material handling planning sheet). Which for calculation using the following formula:

$$\text{Max } Z = \sum_{i=1}^m \sum_{j=1}^m f_{ij} x_{ij} \tag{1}$$

Table 1. The Value of Adjacency Based Scoring for Initial Layout

From	To	Inflow Coefficient	Rank	Rating	Score	Value of ABS
Finishing area	Circular Saw Machine	1.17	1	A	16	16
Radial Drilling Machine	- Circular Saw Machine	1.04	2	A	16	0
Painting Area	- drying area	1.04	3	A	16	16
Packing Area	- Warehouse	1	4	A	16	16
Welding Machine	Finishing Area	0.96	5	E	8	8
Finishing area	- Packing Area	0.94	6	E	8	0
Storage	- Cutting Area	0.89	7	E	8	0
Cutting Area	- Puttying Area	0.74	8	E	8	8
Patching area	- drying area	0.69	9	E	8	8
Patching area	- Puttying Area	0.51	10	I	4	0
Auxiliary storage	- Painting Area	0.39	11	I	4	0
Finishing Area	- Radial Drilling Machine	0.33	12	I	4	0
Puttying area	- Painting Area	0.3	13	I	4	4
Auxiliary storage	- Puttying area	0.26	14	I	4	4
Warehouse	- Circular Saw Machine	0.2	15	O	2	2
Welding Machine	Radial Drilling Machine	0.15	16	O	2	2
Cutting Area	- drying area	0.11	17	O	2	2
Auxiliary storage	- Patching area Puttying area	0.07	18	O	2	2
Auxiliary storage	- Packing Area	0.06	19	O	2	2
Auxiliary storage	- Welding Machine	0.05	20	O	2	2
Auxiliary storage	- Finishing Area	0.04	21	U	1	1
Patching area	- Finishing Area	0.04	22	U	1	1
Finishing area	- drying area	0.03	23	U	1	1
Total Score					139	95
Percentage of Adjacency Based Scoring					68%	

The value of the Adjacency Based Scoring for initial layout is 68% that is mean the layout must to be improved to reduce cost by maximizing adjacency of highly interacting machines or work station or reducing material handling cost or distance between work stations. Facility layout design requires diverse field of knowledge. Among other the application and use of computers become an advantage. The computerized layout methods, either construction or improvement-type routines are heuristics. Construction-type layout routine generates a block layout based on the relationship between different departments. Automated Layout Program design (ALDEP) is commonly use software for construction-type layout. A newly constructed layout alone will not be nearly optimal, the new construction must be evaluated by an improvement routine. The most popular improvement-type methods are Computerized Relative Allocation of Facilities Technique (CRAFT).

Before designing a new layout, the number of machines needed must be checked using Routing Sheet. From the Routing sheet of CV. Aji Jaya Mandiri the number of machines which need to be increase are 3 machines there are Grinding, adjustable work benches 1, adjustable work benches as seen below.

Table 2. Number of Machines

No	Machine	Number of machine/work station	Number of machine	Number of machine/Station	Number of machine (round-up)	Number of machine available	+/-
		Two Way	Bench				
1	Circular Saw Machine	0.087	0.286	0.373	1	1	0
2	Drying Area	0.295	0.128	0.423	1	1	0
3	Radial Drilling Machine	0.105	0.667	0.772	1	1	0
4	Spray Gun	0.071	0	0.071	1	1	0
5	Welding Machine	0.48	0.501	0.981	1	2	-1
6	Grinding Machine	0.929	1.462	2.391	3	2	+1
7	Adjustable Work benches 1	0	0.258	0.258	1	0	+1
8	Adjustable Work Benches 2	0	0.198	0.198	1	0	+1
9	Packing Area	0.037	0.084	0.121	1	1	0
10	Work Table	0.108	0.114	0.222	1	0	+1
11	Cutting Table	0.04	0.103	0.143	1	1	0

From to Chart made after the number of machines will be arranged, are obtained from the routing sheet and compared to the number of machines available. The space of Department of specified machine was defined and then calculated the distance between the departments multiplied by the number of products being transferred and the frequency of removal to get the cost of material handling between Department.

To determine the rating of closeness used coefficient of inflow that calculate from the chart above (formula 2), which can be seen below. The coefficient then used as closeness rating A,E,I,U and X. The quantitative methods used to design the layout, particularly concerning the transfer of material with the minimal possible distance. Furthermore, the results of calculations used as input from FTC Inflow, which for calculation using the following formula:

$$FTC\ Inflow = \frac{FTC\ Cost}{total\ column\ per\ machine} \tag{2}$$

- Legend:
- | | | | |
|---|--------------------------------|----|---------------------------|
| X | Storage | 6 | Grinding Machine |
| Y | Storage of Auxiliary Materials | 7 | Adjustable Work Benches 1 |
| 1 | Circular Saw Machine | 8 | Adjustable Work Benches 2 |
| 2 | Drying Area | 9 | Packing Area |
| 3 | Radial Drilling Machine | 10 | Work Table |
| 4 | Spray Gun | 11 | Cutting Table |
| 5 | Las Machine | Z | Warehouse |

Table 3. From to Chart Between Department

From\To	X	Y	1	2	3	4	5	6	7	8	9	10	11	Z	Total
X			112087.1										47935.32		160022.4
Y						35063.2	19284.76	2713.32	12324.2	37772.92	12792.22	17606			137556.62
1					192643.4			264551.1							457194.51
2						21777.08		20770.56	30286.8				11033.49		83867.93
3			25127.4				54684.5	124288.5							204100.35
4				224471.4											224471.44
5								108412.5							108412.5
6			267998				208152					22597.9			498747.93
7				37017.2								11830.14			48847.34
8						22664.88			37098.6						59763.48
9													84842.52		84842.52
10										85208.68					85208.68
11									60391.18						60391.18
Z															0
Total	0	0	405212.5	261488.6	192643.4	79505.16	282121.3	520735.9	79709.6	98164.1	98000.9	52034.04	58988.81	84842.52	2213426.88

Table 4. Coefficient of Inflow

	X	Y	1	2	3	4	5	6	7	8	9	10	11	Z	Total
X			0.28										0.81		1.09
Y						0.44	0.24	0.69	0.16	0.48	0.16	0.22			2.39
1					1.06	0.86		0.51							2.43
2						0.27		0.04	0.38	0.14			0.19		1.02
3							0.19	0.24							0.43
4										0.29					0.29
5								0.95							0.95
6												0.43			0.43
7										0.47		0.23			0.7
8													0.62		0.62
9												0.87		1	1.87
10															0
11															0
Z															0
Total	0	0	0.28	0	1.06	1.57	0.43	2.43	0.54	1.38	0.16	1.75	1.62	1	12.22

ALDEP allows the department to provide specific placed and can enter a dummy. Design with Algorithm ALDEP is subdivided into 2 procedures i.e. procedures of selection and placement procedures [3]. Input is needed to run the software of ALDEP it is the maximum value of TCR (Total Closeness Rating), the number and area of the Department that will be iterated, spacious layout dimensions and the minimum degree of closeness of relationship that is used.

The first elected Department to get done at random, for the next selected departments taken from departments that have a relationship "A" with the Department's first elected, if there is more than one Department, which is worth A then the Department will be selected randomly, but when there is no Department of value A, then Department of equal value or the value is equal to the lower limit of the level of closeness that is already put before by the user will be elected. The next selected departments in a manner that is similar to the previous one, this process is continued until the entire Department goes into the layout.

Procedure for placement on the first Department of ALDEP i.e. placing selected at the top left corner of the layout and continued towards the bottom. The length and width layout is determined by the user who entered earlier. This is also known as placement process with vertical sweep pattern (vertical road pattern). Total Closeness Rating (TCR) score become input in using software ALDEP can be seen at Table 1 below. Space available that is 447.11 m2, but as an input of ALDEP it is inserted in the template that is the number of 117 unit with a length of 13 and a width of 9. The number of departments that will be as much iteration 14 departments. Minimum degree of relationship of the TCR already calculated earlier U (unimportant).

Table 5. Total Closeness Rating

From\To	X	Y	1	2	3	4	5	6	7	8	9	10	11	Z	Total
X		U	O	U	U	U	U	U	U	U	U	E	U	U	21
Y			U	U	U	I	O	E	U	E	U	O	U	U	31
1				U	A	A	U	E	I	U	U	U	U	U	51
2					U	O	U	U	U	U	U	U	O	U	12
3						U	O	U	U	U	U	U	U	U	11
4							U	U	U	I	U	U	U	U	11
5								A	U	U	U	U	U	U	22
6									U	I	U	I	U	U	12
7										U	U	O	U	U	6
8											U	U	E	U	11
9												A	U	A	33
10													U	U	2
11														U	1
Z															0
Total	0	1	2	1	1	1	1	1	1	1	1	8	1	1	224

The data processing software of ALDEP found optimum layout design of a product, with closeness rating 630, can be seen in Figure 6 as follows.

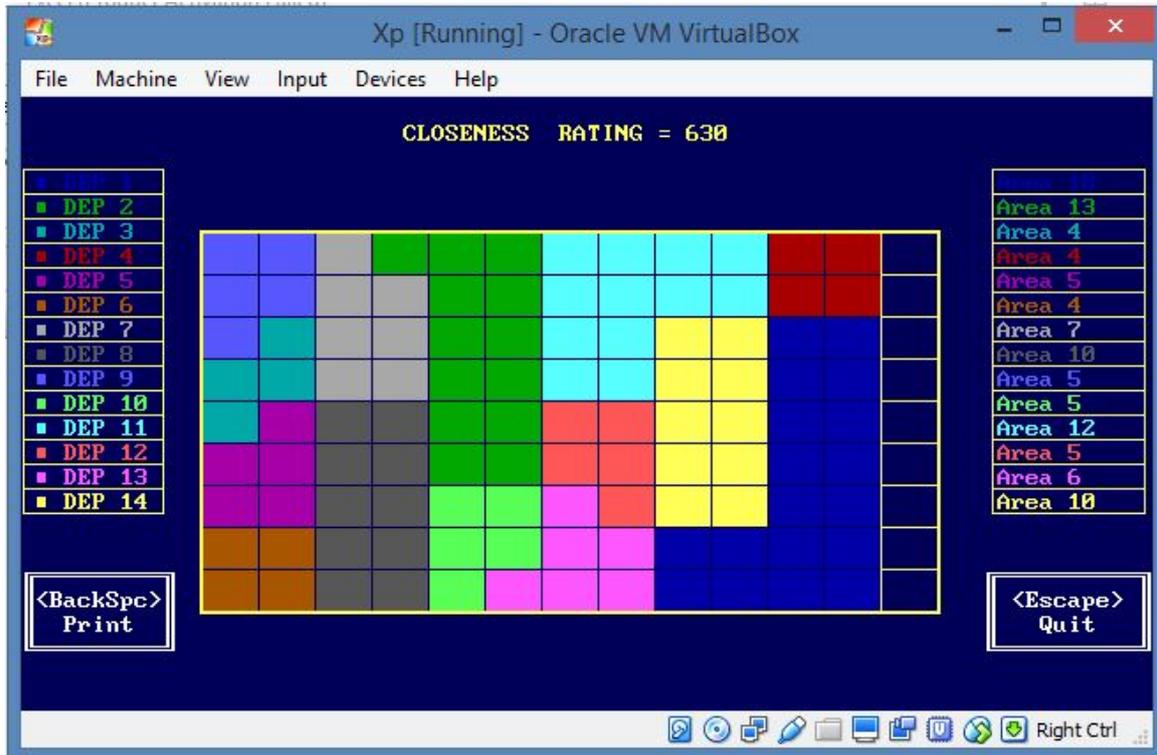


Figure 1. The optimum layout from ALDEP software

Improvement-type routines require an input from ALDEP block layout and aim to reduce internal transport cost by attempting simultaneous pair-wise position exchanging among the departments. The basic concept of the CRAFT is the exchange location/department activities on initial layout in order to find a better solution based on the flow of materials. Exchange will further bring to facility layout direction approaching the optimum costs. Algorithm of CRAFT can exchange 2 or 3 departments, so it can be used to generate a better layout. [4]. The data required as input CRAFT:

1. Initial layout from ALDEP block plan
2. Flow of material (frequency displacement)
3. Cost (material handling cost per meter)
4. The number of departments that have not changed (fixed)

CRAFT is a useful for improve the previous layout. The result layout obtained from CRAFT software as follows can be seen in Figure 2. MHES is a table used to calculate the cost of materials handling. MHES optimize the flow of materials by planning a sequence of operations and equipment settings. Material handling used here is manual, where the operator performs the transfer of materials from one Department to another Department. The result of the calculation of the MHPS will be as input for the FTC. Unlike the Material Handling Planning Sheet (MHPS), the Material Handling Evaluation Sheet (MHES) using real distance from the layout. The distance in the study using aisle distance. The purpose of doing an evaluation of the design of the layout using material handling that is to know the difference in the cost of material handling. Evaluation performed towards the cost of material handling on the layout of ALDEP and layout of the CRAFT, The Material Handling cost of proposed layout from ALDEP was Rp. 2,562,331, which when compared with the improved layout of the results of CRAFT

was Rp. 2,402,358, the results of CRAFT showed a decrease in the cost of material handling Rp. 159,973 (6,24%)

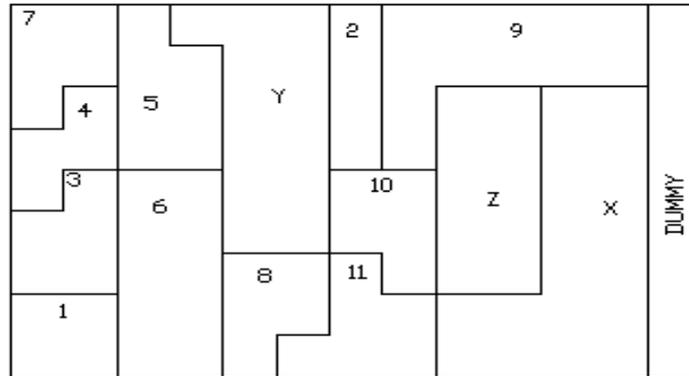


Figure 2. Output CRAFT Layout

Simulation is a tool that can be used to predict performance. The simulation could not design a system by itself. The user must provide various design scenarios and evaluate each scenario simulation tool to determine which scenario has the best performance. The simulation can also be defined as a technique that mimics the operation of the computer manufacturing real or system services from time to time. [5]. In the simulation model development, the basic elements are required are location, entities, arrival, processing and resource.

Table 6. The Result of Evaluation Layout with Adjacency Based Scoring

From	To	Rank	Rating	Score	ALDEP	CRAFT	
Circular Saw Machine	Radial Drilling Machine	1.06	1	A	16	16	
Packing Area	Warehouse	1	2	A	16	16	
Las Machine	Grinding Machine	0.95	3	A	16	16	
Packing Area	Work Table	0.87	4	A	16	16	
Circular Saw Machine	Spray Gun	0.86	5	A	16	0	
Warehouse	Cutting Table	0.81	6	E	8	8	
Auxiliary storage	Grinding Machine	0.69	7	E	8	8	
Awb2	Cutting Table	0.62	8	E	8	8	
Circular Saw Machine	Grinding Machine	0.51	9	E	8	8	
Auxiliary storage	Adjustable Work Benches 2	0.48	10	E	8	8	
Adjustable Work Benches 1	Adjustable Work Benches 2	0.47	11	I	4	0	
Auxiliary storage	Spray Gun	0.44	12	I	4	4	
Grinding Machine	Work Table	0.43	13	I	4	4	
Drying Area	Adjustable Work Benches 1	0.38	14	I	4	0	
Spray Gun	Adjustable Work Benches 2	0.29	15	I	4	0	
Warehouse	Circular Saw Machine	0.28	16	I	4	0	
Drying Area	Spray Gun	0.27	17	O	2	2	
Auxiliary storage	Las Machine	0.24	18	O	2	2	
Radial Drilling Machine	Grinding Machine	0.24	19	O	2	2	
Adjustable Work Benches 1	Work Table	0.23	20	O	2	2	
Auxiliary storage	Work Table	0.22	21	O	2	2	
Drying Area	Cutting Table	0.19	22	O	2	2	
Radial Drilling Machine	Las Machine	0.19	23	O	2	2	
Auxiliary storage	Adjustable Work Benches 1	0.16	24	U	1	1	
Auxiliary storage	Packing Area	0.16	25	U	1	1	
Drying Area	Adjustable Work Benches 2	0.14	26	U	1	1	
Dying Area	Grinding Machine	0.04	27	U	1	1	
Total Score					162	130	134
Percentage of Adjacency Based Score						80%	83%

This percentage of adjacency based score by applying ALDEP algorithm followed by improvement routine methodology CRAFT was better than that of ALDEP construction routine alone. Evaluation of improved layout resulted from CRAFT generate Adjacency Based Score percentage of 83% than 80% of ALDEP. There are also significant consistency between the cost of Material handling, and manufacturing lead time. There are also significant consistency between the cost of Material handling and manufacturing lead time.

4. Conclusion

This paper has shown federated usage of construction and improvement routine results better performance of factory layouts. The improved layout of CRAFT was the best layout according to the cost of material handling, manufacturing lead time and adjacency based score. Further research can be apply in other industries and other method of construction as well improvement type algorithmic.

5. References

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