



Facility Layout Planning for Pyrolyzer Production Using Automated Layouts Design Program (ALDEP) Method

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ABSTRACT

One important factor to consider in increasing productivity in a company is the design of the facility layout. PT Hari Mukti Teknik is keen producing pyrolysis machine to contribute to addressing waste issue in Indonesia. Currently, the facility layout at the company is not suitable to produce pyrolyzers as it was set up to produce industrial scale washing machines. To improve production efficiency, PT Hari Mukti Teknik needs facility layout that can be optimized for pyrolyzers. The purpose of this study is to provide a layout design proposal for the pyrolysis machine manufacturing process to obtain an effective and efficient process. Here, we used ALDEP method to produce layouts based on consideration of the level of relationship between departments. There were 4 alternatives for the manufacturing and production and two alternative layouts for employee and office area. The design for new layout was selected based on the closeness relationship between the departments. An overall facility layout plan that is required for the production of pyrolysis machines is a building area the total of 1045 m² covering manufacturing, production, employee, office and parking space areas.

Keywords: production system, facility layout, automated layouts design program (ALDEP), pyrolyzer

1. INTRODUCTION

Manufacturing companies must promptly be able to adjust to any changes in business requirements, for example when producing new products. PT Hari Mukti Teknik (HMT) is a company engaged in manufacturing machinery, specifically in the production of industrial scale washing machines. PT HMT is one of many companies impacted by recent Covid-19 pandemics. Their products suffered from plummeting sale, compelling them to quickly reflect on their business and production. The company has shown interest in waste management as waste is a complicated problem in Indonesia and has been unsolved for decades. As a manufacturing company with the ability to produce industrial scale machinery, PT HMT has delved into designing developing pyrolysis machines (pyrolyzers).

Waste in Indonesia are mostly not segregated and directly dumped into landfills (open dumping). Other waste management method that is frequently used in Indonesia is

controlled landfill method, which is an improvement from open dumping. In controlled landfill, waste is covered with soil in regular basis to reduce the harm caused to the environment. These methods, however, are not environmentally friendly as the waste will keep on piling each day. Waste should be reduced and there are methods available to do this, including incineration, composting, reuse, and recycle. Unfortunately, these methods are not commonly used. Indonesia produced around 65 million of waste every day, most were organic waste (60%) followed by plastic (14%) (waste4change, 2020). As the waste is not separated at source, it becomes much more challenging to implement solutions like composting (for organic waste) and recycling (for plastic). The waste must be sorted first and then treated (such as by washing and drying the plastics). Therefore, other method such as pyrolysis can be a suitable alternative solution to reduce the amount of waste in Indonesia. It is a material decomposition process at high temperatures that takes place with



limited or absence of air. With this approach, waste can be processed into oil. In addition to reducing waste accumulation in landfills, the process also produces by-products that can be utilized including gas, tar and char.

In the production of pyrolyzers, one of the important factors to improve the manufacturing process is the facility layout. The current layout at PT HMT is not designed to produce pyrolyzers and it was meant to be for the manufacture of industrial scale washing machines. The location of production equipment in the plant is a decisive factor in improving pyrolyzer production efficiency. Facilities layout that is designed incorrectly results in possible losses (Krishnan, Jithavech, & Liao, 2009). There is also a close relationship between the optimizing manufacturing process and the available surface (John et al., 2013; John & E, 2013; Manivel & Sandeep, 2014).

This study aims to propose the best layout to minimize travel distance, material handling, and losses in the pyrolyzer machine production process, using the Automated Layout Design Program (ALDEP) method. This method is shown to improve production effectivity as reported in previous studies (Budianto et al., 2020; Deshpande et al., 2016; Suhardini & Rahmawati, 2019).

2. LITERATURE REVIEW

Four general layout types are Product Layout, Process Layout, Group Technology Layout and Layout by Fixed Position (Hadiguna & Setiawan, 2008). In solving the problem of facility layout, there are 2 methods that can be used:

- 1) **Optimization Method** produces optimal solutions but requires a long completion time. All algorithms for layout problems require very high memory requirements and computation which increase exponentially as the size of the problem increases.
- 2) **Heuristic Method** can be categorized into 3 types, i.e., construction method, improvement method, and hybrid method.
 - a) *Construction Method* generates a new layout regardless of the existing layout, i.e., the design starts from an empty layout. Automated Layout Design Program (ALDEP) is one of many construction method to develop layouts.

The algorithm builds the layout based on the most related departments, size and on the closeness rating. Other examples of this method includes Computerized Relationship Layout Technique (CORELAP) method and Plan Layout and Evaluation Technique (PLANET).

- b) *Improvement Method* is a simple approach, easy to understand and implement. The method refines the initial layout solution that has been deemed feasible. It systematically modifies the initial solution and evaluates the modified solution. Examples of methods that use repair algorithms are Computerized Relative Allocation (COFAD) and Micro Computerized Relative Allocation of Facilities Technique (MICRO-CRAFT).
- c) *Hybrid Method* is a combination of the two methods previously described. An example of a method that uses a hybrid algorithm is BLOCPLAN.

Previous studies have discussed the design of layouts using several approaches. For example, CORELAP software has been utilized to improve factory layout. By using this software, handling cost is estimated to reduce 65% whereas handling distance decreases by 39.5% (Hanum, 2021). Another study using the same method is shown to shorten material handling distance by 9% when applied for packaging area in a pharmaceutical company (Hakim & Istiyanti, 2015). A study using BLOCPLAN algorithm has also shown to improve layout facilities in SMEs in Indonesia. Implementation of the new layout can considerably reduce displacement level by 40% (Putri & Dona, 2019). Other studies have also analyzed layouts arrangement using the heuristic method. This approach is often used for a more complex problems such as utilizing Particle Swarm Optimization to solve for unequal-area static and dynamic facility layout (Derakhshan Asl & Wong, 2017). Another study investigates three meta-heuristic algorithms, namely migrating bird optimization (MBO), tabu search (TS) and simulated annealing (SA) to optimize hospital facility layout problems. Among the three methods, MBO and SA are shown to have the best result, i.e., improving efficiency by 58%



(Tongur, Hacibeyoglu, & Ulker, 2020). The latter method has also been used for the design of the furniture industry layout with a single and double row layout model (Kusumaningsih et al., 2022). The ALDEP method has also been used to improve facility layout problems. This approach has been discussed in the literature, such as using ALDEP to improve in wooden craft productions (Adiyanto & Paldo, 2019) and food industries (Yunanto, Donoriyanto, & Tranggono, 2020). In this study, we use ALDEP method to optimize facility layout for pyrolysis production, which to the best of our knowledge has not been discussed previously.

3. METHOD

The object of the study was the production layout at PT HMT for producing pyrolysis machine. First, direct observation was conducted at PT HMT to identify problem on the shop floor and evaluate existing facility layout for producing pyrolysis machines. The next step was to the required data such as include the Operation Process Chart (OPC), data on facilities and tools, an overview of the existing layout, as well as the number of workers and the company's management structure.

The method used in this study was ALDEP. The design with this algorithm is divided into 2 procedures: the selection procedure and the placement procedure. After several alternative layouts are attained, the layout score of each layout is calculated and then compared to obtain the layout with the best score (Tompkins, 1996). The ALDEP algorithm produced several alternatives based on the proximity value between facilities. The best layout was then selected based on the highest TCL layout value. Layout from output results from the selected ALDEP algorithm were further transformed into a new facility layout design based on data on the size and shape of real facilities in the field.

Data processing carried out in this study is summarized in the following:

- 1) Facility requirements needed for the pyrolysis machine production process
- 2) Creation of facility space requirement worksheet
- 3) Creation of area allocation for each facility
- 4) ARC creation of the entire facility
- 5) Layout design

- 6) Using ALDEP Software
- 7) Selection of alternative solutions
- 8) Making facility layout design

4. RESULTS AND DISCUSSION

4.1 Facility Requirements

Layout design for production facilities was based on the Operation Process Chart (OPC) of pyrolyzer machines. OPC was used to determine the flow of material movement and the sequence of the production process from the beginning of the manufacturing process to the end as well as inspections at each manufacturing step. It also served as a basis for consideration in determining the proximity relationship between the facilities used. OPC also provided other information related to the production process including standard time, processing time, operating time, facilities used, and process information.

Table 1 Manufacture area requirement.

	Quantity	W (m)	L (m)	Area (m ²)
A. Fabrication				
Rolling Machine	1	3.75	1.06	3.98
Plate Cutting Machine	1	2	4	8
Pipe Cutting Machine	1	4	5	20
Bending Machine	1	1.5	4	6
Lathe and Drill Machine	1	2	3	6
B. Assembly Station	3	2	9	54
C. Painting Station	1	5	10	50
D. Packaging Station	1	3	9	27
Subtotal				174.98
50% allowance				87.49
Total				262.47

Layout of machine facilities was based on production flow and function. In the production process, there are 2 types of cutting machines, i.e., plate cutting machine and pipe cutting machine. There are 1 rolling machine and 1 bending machine, and also there is 1 drilling and lathe machine. In addition, there is 1 that is used to perform welding on components



in the assembly station. Based on the production flow, the existing machines are positioned in close proximity due to production lines that are interrelated to one another.

4.2 Space Requirement

Five areas were analyzed to determine the space requirements, considering allowances for moving space and isles so that the pyrolysis machine production process can run effectively. These are the manufacturing area (**Table 1**), production service area (**Table 2**), employee service area (**Table 3**), office area (**Table 4**), and parking area (**Table 5**).

Table 2 Production service area requirement.

	Quantity	W (m)	L (m)	Area (m ²)
Receiving and Shipping	1	4.6	13.3	61.18
Quality Control	1	2	3	6
Warehousing raw material	1	5	7	35
Warehousing finished good	5	1.6	5.5	44
Maintenance & Tool Room	1	2	3	6
Utilities (Electricity)	1	2	2	4
Subtotal				156.18
50% allowance				78.09
Total				234.27

4.3 Area Allocation

Small blocks in the arrangement were used to determine area allocation. First, the number of blocks required by each workstation were determined (a size 4m² block was used). As shown in **Table 6**, the total blocks required are 81 blocks. The total are required is 1045 m² or equivalent to 274 blocks.

4.4 REL Chart

The activity relationship diagram or REL chart contains the degree of relationship between departments which is determined based on several considerations, such as the presence or absence of material handling, ease of movement for workers, comfort, and safety. There are five degrees of closeness used in this diagram, namely A (absolutely necessary), E (especially important), I (important), O (ordinary

importance), U (unimportant), X (closeness undesirable). Here, the REL Chart for pyrolysis machine is shown in **Figure 1**.

Table 3 Employee service area requirement.

	Quantity	W (m)	L (m)	Area (m ²)
Toilet	5	1.5	2	15
Locker	40	0.5	0.5	10
Cafeteria	1	2	2	4
Medical Services	1	3	3	9
Prayers Room	1	5	5	25
Subtotal				156.18
50% allowance				78.09
Total				234.27

Table 4 Office area requirement.

	Quantity	W (m)	L (m)	Area (m ²)
HRD Office	1	4	6	24
Marketing Office	1	2	4	8
Financial Office	1	2	4	8
RND Management	1	3	4	12
Director Office	1	3	4	12
HRD Office	1	4	6	24
Subtotal				64.00
50% allowance				32.00
Total				234.27

Table 5 Parking space area requirement.

	Quantity	W (m)	L (m)	Area (m ²)
Employee parking	24	0.7	2	33.6
Office parking				
Car	11	2.5	4.5	123.75
Motorbike	7	0.7	2	9.8
Visitor parking	5	2.1	3.5	36.75
Subtotal				203.90
75% allowance				152.93
Total				234.27

**Table 6** Block Requirements for each Department.

Num	Department or Workstation	Area (m ²)	Area + Allowance (m ²)	Blok Required / 4 m ²
1	Rolling Machine	3.98	59.63	2
2	Plate Cutting Machine	8	12	3
3	Pipe Cutting Machine	20	30	8
4	Bending Machine	6	9	3
5	Lathe and Drill Machine	6	9	3
6	B. Assembly Station	54	81	21
7	C. Painting Station	50	75	19
8	D. Packaging Station	27	40.5	11
9	Receiving and Shipping	61.18	91.77	23
10	Quality Control	6	9	3
11	Warehousing raw material	35	52.5	14
12	Warehousing finished good	44	66	17
13	Maintenance & Tool Room	6	9	3
14	Utilities (Electricity)	4	6	2
15	Toilet	15	22.5	6
16	Locker	10	15	4
17	Cafeteria	4	6	2
18	Medical Services	9	13.5	4
19	Prayers Room	25	37.5	10
20	HRD Office	24	36	9
21	Marketing Office	8	12	3
22	Financial Office	8	12	3
23	RND Management	12	18	5
24	Director Office	12	18	5
25	Employee parking	33.6	58.8	15
26	Office parking	133.55	233.71	59
27	Visitor parking	36.75	643.13	17

4.5 Layout Planning Using ALDEP

In designing the layout of this facility, two separate layout designs were carried out: 1) the manufacturing and production service areas, 2) the employee services and the office area. Office area and employee area must be designed separately from the manufacturing and production service areas because they have a tendency for X or undesirable activity degree values. Meanwhile, the parking space area was not designed using ALDEP software because its position was not in direct contact with the inside area and its placement adjusted to the departments in the inside area.

4.4.1 Manufacturing and Production Service Layout Design

Three steps must be taken in designing a facility layout using ALDEP software. The first step is to input the required land area, the number of departments used, the minimum degree of relationship, the minimum activity relationship value, the desired number of iterations, and the block size in square meters. In this design data is entered according to the following basis:

- The required area is 497 m², but in ALDEP it is necessary to multiply the length by the width with a round number so a size of 32 mx16 m is used. A length-to-width ratio of 2:1 in building design is highly recommended as it facilitates material flow and accessibility (Stephens & Meyers, 2013).
- The amount of required Department is 14 that can be seen in table 4.5.1.
- Minimum degree of relationship is A.
- The number of layouts per iterations is 2
- Block size is 4 m²

The second step is to input the area of the 14 departments as shown in in **Table 6**. The third step is to input the value of the degree of activity relationship according to the REL Chart.

Four layouts were obtained from using ALDEP software (shown in **Figure 2**).

4.4.2 Office and Employee Service Area Layout Design



Table 7 TCR of the alternative layouts.

Manufacturing & Production		Employee & Office	
Alternative	TCR	Alternative	TCR
1	1440	1	100
2	1592	2	138
3	1624		
4	1688		

4.7 Facility Layout Design

Based on the chosen alternative solution, an overall facility and production layout plan was made consisting of 27 departments. A total building area of 1045 m² were needed and the proposed facility layout can be seen in **Figure 3**.

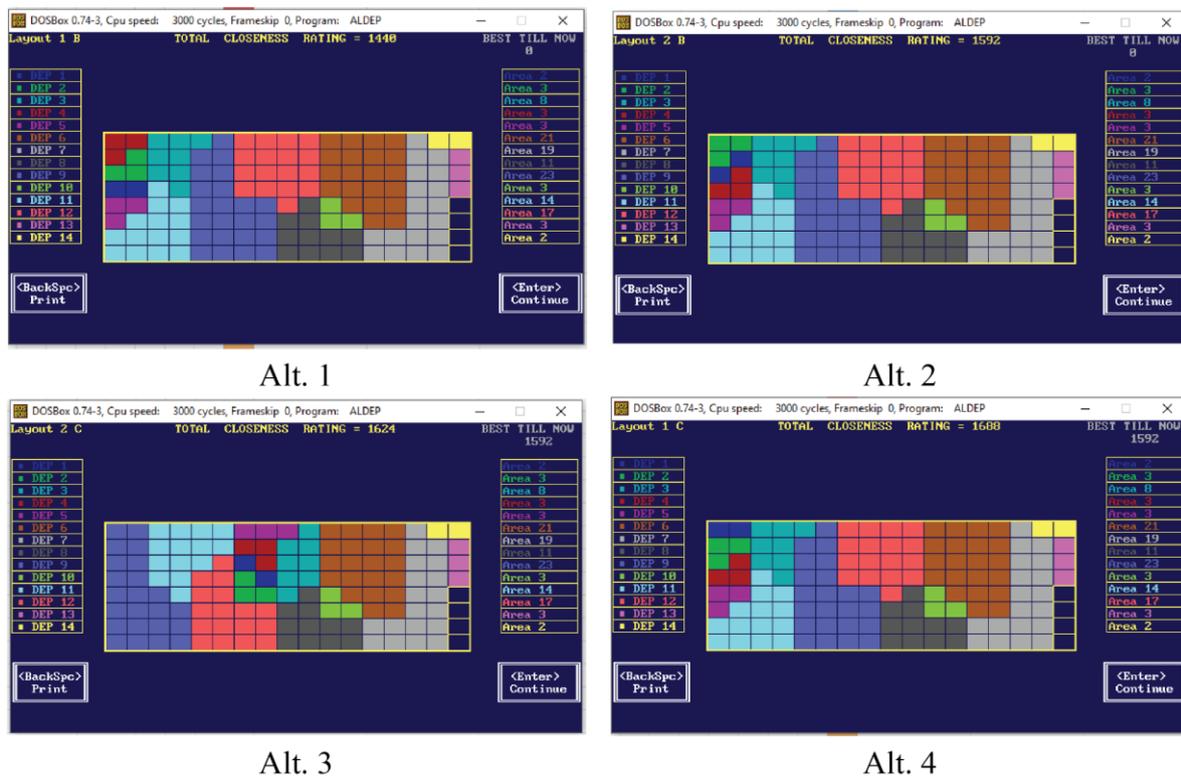


Figure 2 Alternative Solution for Manufacturing and Production Area.



Figure 3 Alternative Solution for Employee and Office Area.



4. CONCLUSION

The layout design to produce pyrolizers at PT HMT was carried out using The Algorithm Layout Design Program (ALDEP) method. The method produced 4 design alternatives for manufacturing and production areas, and 2 design alternatives for office and employee areas. The design alternative chosen for manufacturing and production areas is the fourth alternative (TCR 1688) and the second alternative for employee and office areas (TCR 138). A layout plan for the overall facility to produce pyrolysis machines was built with a total building area of 1045 m² which includes manufacturing, production, employee, office, and parking areas.

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