Redesigning production floor layout with process layout and product layout approach in an electronic appliance manufacturing company

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Abstract. The system of material handling is less systematic becomes a big problem and disrupts the smoothness of the production process that affects the system as a whole. Problems that occur in the company is a workstation that is too dense so that the trajectory of material handling (forklift) becomes narrow, in addition, there are also workstations that are located too far, causing empty space in the production floor area. This long-distance resulted in a great displacement moment that affected the amount of material handling cost. Therefore, it’s important to redesigning the facility layout to reduce material handling cost at the company. The goal of this research is to get an optimal design of facilities layout that provides minimal displacement moment by comparing the initial layout with the proposed layout with Process Layout and Product Layout approach. Process Layout is designed using graph theory while the product layout is designed using the method of Systematic Layout Planning. After that, the layout of the production floor with the product layout approach improves material handling efficiency with the displacement moment of the proposed production floor layout is 36.160 meters per year or 19.4% lower than the actual layout.

1. Introduction
Facilities can be defined as buildings where men, materials, and machines gather for other purposes [1]. The systematic and functional arrangement of the various departments, equipment, machinery, and services in the manufacturing industry is called the facility layout [2]. The layout of the facility is part of the design of a facility that is more focused on regulating physical elements. Physical elements can be in the form of machinery, equipment, tables, buildings, and so on. Rules or logic settings can be in the form of determination of objective functions such as total distance or total cost of material transfer [3]. Good layout planning will integrate production planning, economic analysis, inventory control, material transfer, quality control, and others [4]. Determination of the most efficient physical arrangement of the building from the number of interacting facilities on the factory floor of a manufacturing system to meet one or more objectives is a problem of facility layout [5]. The benefits of FLP are: fast and easy, complexity is minimal and easy to implement, controlled, and interactive and flexible and improvable [6]. The goal of planning the layout of a facility is to get a design or layout of physical facilities that can support the implementation of all activities and production operations in an efficient plant location that integrates production planning, economic analysis, inventory control, material transfer, quality control, and others. The design of production facilities is
one of the factors that influence the performance of a company. Poor facility layout will lead to poor material flow patterns, and relatively high flow and movement of materials, labor, products, equipment and information will result in long product completion times and increase costs of production [7].

The current state of the production floor in the company is still not well structured due to the presence of too tight a work station so that the material handling track space (forklift) becomes narrow, besides that there is also a work station that is too far away to create empty space in the production floor area. This long-distance causes the moment of displacement to be large so that it impacts on the number of material handling costs. Based on preliminary observations, the total moment of displacement in this company is 44860 meters per year. This large total moment of displacement can increase material handling cost so it needs to be reduced.

Activities related to the design of the physical element structure of activity and always closely related to the manufacturing industry, where the depiction of the design results is called plant layout. And good layout always involves procedures for transferring materials at the plant, so that it is then called plant layout and material handling [8]. To overcome the layout problems that occur, the Process Layout and Product Layout is used. Product Layout can be defined as a method or method of organizing and placing all required production facilities in a particular department or specifically. A product can be made or produced to be finished within the department. In Process/Functional Layout all operations with the same nature are grouped in the same department in a factory/industry. Machines, equipment that has the same function are grouped together for example, all lathes are made into one department, drilling machines are made into one department, and mills are made as one department [9]. The Process Layout method used in this study is the graph method while the Product Layout method used in this study is the Systematic Layout Planning method.

Systematic Layout Planning is a tool used to manage workplaces in factories by finding two areas with high frequency and logical relationships that are close to each other [10]. This SLP step has been widely applied in designing both assembly lines to service [11]. The steps in SLP planning are as follows: Data collection and activity, material flow analysis and activities, relationship chart activities, relationship diagrams, area requirements and available, and the last design layout. Layout design using the graphical method is basically almost the same as the SLP method. As the basis for making this layout design, SLP uses a linked activity map or from-to-chart. The graph method is a layout design method that uses a proximity graph as a connection between departments or existing facilities to obtain the greatest weight. The graph method procedure used to make a proximity graph which is done step by step by giving priority to the pairs of departments that have the greatest proximity weight [12].

2. Research method
The method used in this study to redesign the factory layout is the Process Layout and Product Layout approaches. Data processing is carried out by following several stages, namely: 1. Depicting the initial block layout of the production floor and factory facilities; The production floor depiction in block layout’s form is done by reviewing the current factory layout; 2. Determination of distances between departments; Distances between departments is measured using rectilinear distances, where distances are measured following a perpendicular path. Department distance is calculated by taking the center point of the department; 3. Determination of frequency of material transfer between departments; The frequency of displacement is determined to show a large number of material handling flows that occur in the production process. The frequency of displacement is determined by the production volume and batch size; 4. The calculation of initial transfer time; The total moment of displacement on the initial production floor can be determined by multiplying the frequency of material transfer from one department to another by the distance between the relevant departments; 5. Facility layout planning using the process layout and product layout approaches; 6. Making the production floor layout; 7. Choosing a draft proposal with the smallest transfer moment.
3. Results and discussion

3.1. Calculation of distance, frequency, and total moment of actual layout displacement

The company’s work station is described in the layout form with the dimension and location as found in the factory. Layout for the production section at PT. ABC can be seen in Figure 1.

![Figure 1. Actual Layout](image)

Determination of the displacement moment on the production floor is done by multiplying the frequency of material transfer from one station to another with the distance between relevant departments [13, 15]. The formula is:

\[ Z_0 = \sum_{i=1}^{n} \sum_{j=1}^{n} f_{ij} d_{ij} \]  

(1)

- \( Z_0 \) = total moment value of initial displacement (meters/year)
- \( f_{ij} \) = frequency of transfer from station i to j
- \( d_{ij} \) = distance between stations i with j

| No | Work Station            | Distance (meter) | Frequency of Transfer (Unit/Year) | Moment of Displacement |
|----|-------------------------|------------------|-----------------------------------|------------------------|
| 1  | Cutting I-Perforation   | 12.2             | 400                               | 4800                   |
| 2  | Cutting II-Welding      | 20.0             | 200                               | 4000                   |
| 3  | Perforation -Bending    | 14.0             | 400                               | 5600                   |
| 4  | Bending-Welding         | 11.5             | 400                               | 4600                   |
| 5  | Welding-Painting        | 24.4             | 600                               | 14640                  |
| 6  | Painting-Drying         | 12.0             | 600                               | 7200                   |
| 7  | Drying-Assembling       | 6.7              | 600                               | 4020                   |
|    | **Total**               |                  |                                   | **44860**              |
3.2. Layout design of process layout oriented

The layout design of process layouts-oriented in this report uses the graphical method. The layout design of process layouts-oriented needs the Multi-Product Process Chart in the design stages that can be seen in Figure 2.

![Figure 2. Multi-Product Process Chart](image)

The results of the layout design of process layout-oriented can be seen in Figure 3.

![Figure 3. Graph Method Result](image)

The allocation of workstations into the layout considers the greatest frequency of movement. Layout with the process layout approach can be seen in Figure 4.

![Figure 4. First Alternative Layout (Process Layout)](image)
The moment of displacement of the graph method can be seen in Table 2.

### Table 2. Distance and Transfer Moment Data on First Alternative Production Floor

| No | Work Station           | Distance (meter) | Frequency of Transfer (Unit/Year) | Moment of Displacement |
|----|------------------------|------------------|-----------------------------------|------------------------|
| 1  | Cutting I-Perforation  | 14.2             | 400                               | 5680                   |
| 2  | Cutting II-Welding     | 17.0             | 200                               | 3400                   |
| 3  | Perforation -Bending  | 15.4             | 400                               | 6160                   |
| 4  | Bending -Welding      | 9.0              | 400                               | 3600                   |
| 5  | Welding-Painting      | 12.8             | 600                               | 7680                   |
| 6  | Painting-Drying       | 11.6             | 600                               | 6960                   |
| 7  | Drying-Assembling     | 12.7             | 600                               | 7620                   |
|    | **Total**             | **41100**        |                                   |                        |

3.3. **Layout design of product layout oriented**

The second alternative layout design in this report uses a systematic layout planning approach. Activity Relationship Chart is used to get relations from certain activities so that activities can be determined which must be close together and activities that must be far apart in a facility layout design. The diagram shows the close relationship between processes and important elements of the department or work station [14, 16]. Activity Relationship Chart can be seen in Figure 5.

![Activity Relationship Chart](image)

**Figure 5.** Activity Relationship Chart
The calculation of distance and moment of displacement on the proposed production floor can be seen in Table 3.

Table 3. Distance and Moment of Transfer Data on the Proposed Production Floor

| No | Work Station          | Distance (meter) | Frequency of Transfer (Unit/Year) | Moment of Displacement |
|----|-----------------------|------------------|----------------------------------|------------------------|
| 1  | Cutting I-Perforation | 9.0              | 400                              | 3600                   |
| 2  | Cutting II-Welding    | 14.6             | 200                              | 2920                   |
| 3  | Perforation-Bending   | 9.2              | 400                              | 3680                   |
| 4  | Bending-Welding       | 11.8             | 400                              | 4720                   |
| 5  | Welding-Painting      | 17.8             | 600                              | 10680                  |
| 6  | Painting-Drying       | 9.0              | 600                              | 5400                   |
| 7  | Drying-Assembling     | 8.6              | 600                              | 5160                   |
|    | **Total**             |                  |                                  | **36160**              |

According to the discussion above, the layout design carried out using the graphical method produces a proposed layout with a total moment of displacement of 41100 meters per year while the layout design carried out using the Systematic Layout Planning method produces a proposed layout with a total moment of displacement of 36160 meters per year. Based on the results obtained the Systematic Layout Planning method or product-based layout design has the lowest total displacement moment and becomes the proposed layout in the company.

4. Conclusion

Based on research, it can be concluded that the moment of displacement’s initial production floor layout at ABC Company is 44860 meters per year. The moment displacement’s proposed layout approach is 41100 meters per year with material handling efficiency of 8.4% from the initial layout. The displacement moment of the proposed production floor layout with the product layout approach is 36160 meters per year with material handling efficiency 19.4%. The proposed production floor layout chosen designs with a product layout approach because it has the lowest total moment of displacement.

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