Proposed improvement of production floor layout using urban algorithm in minimizing the cost of material handling (Case study of rubber wood processing factory)

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Abstract. The design of the layout of the production floor facilities in this study aims to solve the problem on the production floor, namely that there is an irregular material flow pattern due to alternating flow and crossing paths with high frequency resulting in total material transfer moment which is directly proportional to high material handling cost. To solve the problem is used Urban Algorithm and WinQSB Software. This method was chosen because it can exchange between departments and move departments so that distant parts can be re-adjacent. In addition, this method uses from to chart which is then inputted to produce alternative layout proposals. The results obtained after repairing the production floor layout using the Urban algorithm and WinQSB software in XYZ Company of wood processing factory shows that the total displacement moment is 546,745 times/month. This has decreased compared to the total moment of displacement of the initial layout of 1,211,335 times/month. The total OMH in the initial layout was IDR 1,321,902 after improvements and adjustments were made using the Urban algorithm, the total OMH was IDR 574,083. The results showed that the layout improvement with the Urban algorithm has an efficiency of 56.57% and the best alternative is layout II.

1. Introduction
Facility layout can be defined as a collection of physical elements that are arranged according to certain rules or logic. The facility layout is part of the facility design which is more focused on the arrangement of physical elements. The Physical elements can be machines, equipment, tables, buildings, and so on. Rules or logic can be set in the form of destination functions such as the total distance or the total cost of moving materials [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 goal of facility planning is to get a physical layout or layout that can support production activities in a facility location efficiently [3]. Good facility layout and in accordance with company conditions is one of the main factors to optimize production time and cost. The facility layout includes planning and setting the location of machines, equipment, flow material, and the people who are working in each work station. The work operational will be more effective and efficient if it was regulated properly [4]. In a factory, material handling absorbs about 25% of the workforce, uses about 55% of the room and 87% of the time of production. Material handling is estimated to use 15% to 70% of total manufacturing costs. Therefore, material handling is an important issue to analyze to reduce costs [5].

Material handling is an art and science that involves movement, handling, and material storage during various stages of manufacture. Through scientific material handling a large cost reduction and production cycle time can be achieved [6,7]. The placement of facilities within the factory area, to determine the most effective arrangement according to several criteria or objectives under, is a problem of facility layout [8,9].

XYZ Company is a company engaged in wood processing which produces various kinds of furniture such as wood rolls, tables, chairs, clothes hangers, etc., all of them are exported abroad.
(Japan and Europe). The production system is Make-To-Order (MTO), where each product is made based on orders from consumers. The company has 13 workstations in its production process.

Based on observations on the production floor, the problems have been found are backtracking from the cutting station (II) to the finger joint station (III) and cross-movement from the finger joint station (III) to the laminating station (IV) and from tapping station (I) to cutting station (II). This results in the length of the displacement moment which is proportional to the high cost of material handling. The actual layout of the company can be seen in Figure 1.

![Figure 1. Actual Layout](image)

The main principle in the Urban algorithm is the steepest-descent-pairwise-interchange whereby exchanges of two or more departments to maximize the reduction in total costs or the smallest OMH. The method used to improve facility layout is The Urban algorithm. The Urban algorithm is an algorithm for improvement. This optimization algorithm design by gradually improving the layout. The Urban Algorithm evaluates the layout by swapping departments, changes between departments are expected to reduce material transfer cost. Next Urban's algorithm makes departmental swaps considerations for the new layout that are done repeatedly to produce the best layout taking into account the costs of material transfer. The Urban algorithm calculation method starts by determining the center point of each department in the initial layout, then calculating the rectilinear distance between the pairs of the center points of each department and storing the results of the calculation in the distance matrix. The algorithm then considers all possible exchanges between two or three departments and then determines the best exchange. The best exchange is the one that most reduces the initial layout value \[10, 11, 12].

The picture generated by the urban algorithm is a square diagram of letters and numbers, the total cost or moment is calculated and the difference between the total cost and moment after adjustment with the previous shows savings. The distance used in the calculation of this algorithm is to use rectilinear distances in general [13].

The objective function of the Urban algorithm can be to use a formula [14]:

\[
F = \sum_{i=1}^{n} \sum_{j=1}^{n} C_{ij} \times W_{ij} \times D_{ij}\tag{1}
\]

Where:
\(C_{ij}\) = Cost/unit of material transfer from department i to department j
\(W_{ij}\) = Frequency of material transfer from department i to department j
Distance from department i to department j

Equation which is used to calculate the material handling costs (OMH) is as follows [11]:

$$OMH / m = \cos t / d$$

(2)

Where:

- $OMH / m$ = Freight cost / meter (Rp/m)
- $cost$ = Operating cost / hour (Rp/hour)
- $d$ = Travel distance / hour (m / h)

So that the cost of moving raw materials can be calculated by the following equation.

$$OMH = (R)(f)(OMH / m)$$

(3)

Where:

- $OMH$ = material handling fee
- $r$ = Distance of displacement (m)
- $f$ = Frequency displacement

2. Methods

This type of research is included in the action research [15]. The object of this research is the layout of the production floor of PT. XYZ, which discusses the layout of facilities in the company. The facility layout redesign was done using WinQSB software so that four alternative proposals were obtained. Then the distance departments are calculated using the method, which is to measure the distance along the route that is passed by the material transporter and then calculate the frequency of movement of each work station. After the displacement frequency is obtained, the total moment of displacement is calculated by the displacement distance times the displacement frequency, then finally the material handling costs are calculated which is affected by the material handling cost per meter, the distance between the work stations that are related, and the frequency of displacement that occurs. Layout comparison is carried out by comparing material handling costs to get the best layout.

3. Results and Discussion

Material handling costs calculation is carried out in the actual layout in Figure 1. Calculation of material handling costs is carried out using equations (2) and equation (3). Calculation of material handling costs result in the actual layout can be seen in Table 1.

| Initial Station | Final Station | Material Handling Costs (IDR) |
|----------------|---------------|-------------------------------|
| Initial Station | Final Station | Material Handling Costs (IDR) |
|----------------|---------------|-------------------------------|
| I              | II            | 338,937                       |
| II             | III           | 217,989                       |
| II             | VI            | 37,357                        |
| II             | VII           | 127,402                       |
| II             | VIII          | 83,806                        |
| III            | IV            | 13,235                        |
| III            | VII           | 4,546                         |
| III            | VIII          | 3,069                         |
| IV             | V             | 28,286                        |
| Total          |               | 1,321,902                     |

The Urban algorithm uses input data in the form of material flow data (from-to chart), the results of the conversion of department size in the form of a grid, and the coordinates of each department. The proposed layout is obtained by exchanging one department for another. This iteration process continues until the Total Contribution value is not possible to be reduced again. If the iteration process has stopped, this means that the Urban algorithm has got the optimal final layout solution. Comparison
of alternative layout proposals obtained from the solution option in the WinQSB software. Each alternative produces a production floor layout image that is mapped in the form of blocks. Then the displacement distance is recalculated, the total moment of displacement and OMH for each alternative. The results of the design of the proposed layout for the four alternatives can be seen in Table 2.

**Table 2. Proposed Layout Design For Fourth Alternative**

| Solution Option               | Distance (m) | Total Moment Displacement (times / month) |
|-------------------------------|--------------|------------------------------------------|
| Improve by Exchanging 2 Dept  | 1336.84      | 1409346                                  |
| Improve by Exchanging 3 Dept  | 872.60       | 546 745                                  |
| Improve by Exchanging 2 then 3 Dept | 1336.84 | 1409346                                  |
| Improve by Exchanging 3 then 2 Dept | 933.78 | 623 526                                  |

Based on Table 2, the best alternative layout seen based on the lowest total displacement moment is on alternative two Improve by Exchanging 3 Dept. From the results of data processing above it appears that the proposed layout displacement distance is smaller than the displacement distance at the initial layout that is from 1,636.69 meters to 872.60 meters. The same thing applies to the total moment of displacement, from 1,211,335 times/month to 546,745 times/month. The results of the proposed layout based on data processing can be seen in Figure 2.

**Figure 2. Proposed Layout**

Based on the proposed layout in Figure 2, calculation of material handling costs that can be seen in Table 3.
Table 3. Cost of Material Handling on Proposed Layout

| Initial Station | Final Station | Material Handling Costs (IDR) |
|-----------------|---------------|------------------------------|
| I               | II            | 43.318                       |
| II              | III           | 34.901                       |
| II              | VI            | 26.899                       |
| II              | VII           | 91.060                       |
| II              | VIII          | 42.272                       |
| III             | IV            | 2793                         |
| III             | VII           | 3443                         |
| III             | VIII          | 1986                         |
| IV              | V             | 11.749                       |
| Total           |               | 574.083                      |

The redesign of the layout of the facilities carried out caused changes in the location of each department. Changes that occur also cause changes in material handling costs and we can calculate the cost change in terms of saving efficiency or moment efficiency [16]. Comparison of material handling costs in the actual layout and proposed layout can be seen in Table 4.

Table 4. Comparison of Actual Cost Layout and Layout Suggestions

| Actual Layout (IDR) | Proposed Layout (IDR) | Difference in Cost (IDR) | Percentage (%) |
|---------------------|------------------------|--------------------------|----------------|
| 1,321.902           | 574.083                | 747.819                  | 56.57          |

Based on Table 4, after making improvements using the Urban algorithm, it can be seen that there was a reduction in costs by IDR 747,819 or by 56.57% of the actual layout.

4. Conclusion
The facility layout re-planning is intended to rearrange facilities on the production floor, to improve backtracking of material flow and reduce material handling costs. The application of the Urban Algorithm by applying WinQSB software raises four alternative solution options, and the best one is II alternative (Improve by Exchanging 3 Department alternative). Based on the analysis, after designing the proposed layout, it turns out that there is no backtracking of material flow and material handling total cost has decreased compared to the actual company layout. The actual layout has a total material handling cost of IDR 1,321,902/month, while the application of the Urban algorithm results in a material handling of IDR 574.083/month, so that there is a cost savings of IDR 747.819/month or 56.57% of the actual layout cost.

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