Facility Layout Redesign with Static Facility Layout Planning (SFLP) and Dynamic Facility Layout Planning (DFLP) at Convection and Computer Embroidery Industry

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Abstract. UD. XYZ is a private company engaged in the convection and computer embroidery industry. This company uses raw materials in the form of fabrics to make various kinds of products such as t-shirts, shirts, training pants, jackets, emblems and various types of clothing. Problems that are being faced by this company is a cross-movement, low efficiency, and layout of facilities that do not consider consumer demand for the product so that it can affect the flow of material and increase material handling costs. Based on these problems, this research was conducted to redesign the layout of facilities with Static Facility Layout Planning (SFLP) and Dynamic Facility Layout Planning (DFLP). The method used in redesigning the layout is software CRAFT (Computerized Relative Allocation of Techniques). After redesigning the facility layout with SFLP, material handling costs amounted to IDR 393,510.01 or a cost reduction of 7.41% while the redesign with DFLP had a total cost amounting to IDR 345,685.11 or a reduction in costs of 18.66%. The results of this study show that the proposed layout chosen is the proposed layout with DFLP.

1. Introduction
The manufacturing industry and services have shown significant progress. However, this development occurred ignoring system design problems. The design of a manufacturing system or service, which is a hierarchical combination of several problems, is a complex activity [1]. The layout is a major foundation in the industrial world. Plant layout (facility layout) can be defined as procedures for regulating factory facilities to support the smooth production process. The arrangement will try to utilize the area for the placement of machines or other production supporting facilities, the smooth movement of material transfers, storage of material (storage) both temporary and permanent, workers' personnel, and so on [2]. Facility planning is an activity to produce facilities that consist of structuring their physical elements, regulating the flow of materials, and guaranteeing the safety of workers. The output of designing facilities is only in the form of a room[3, 4]. Static Facility Layout Planning (SFLP) is a plan to regulate physical facilities in an area to achieve cost reduction goals. In environments where material handling flow has not changed for a long time, static layout analysis is sufficient. However, due to competitive and unstable market conditions, manufacturing companies currently operate in a dynamic environment. Therefore, a Dynamic Facility Layout Planning (DFLP) is based on a multi-period
planning horizon [5]. In a static layout, the material flow between machines is constant and the optimal layout is designed for a single time period. Conversely, if the layout is evaluated and modified occasionally with respect to changes in material flow, it is called dynamic layout [6].

The factory must be able to respond quickly to changes in demand, production volume, and product mix. Dynamic layout problems take into account the possible changes in material handling flow over several periods. In this case, the planning horizon is generally divided into periods that can be defined in weeks, months, or years. The layout plan for dynamic layout problems consists of a series of layouts, each layout associated with a period [7].

UD. XYZ is a private company engaged in the convection and computer embroidery industry. The production flow for each product produced is different between one product and another product. The following is data on consumer demand.

Table 1. Data on number of product demands in February - April 2019

| No. | Product Type               | Amount of Demand (unit) |
|-----|----------------------------|-------------------------|
|     |                            | February | March | April  |
| 1   | Embroidery                 | 164      | 96    | 272    |
| 2   | Trousers                   | 62       | 50    | 0      |
| 3   | Pants Training             | 0        | 153   | 53     |
| 4   | Aprons with embroidery     | 0        | 0     | 10     |
| 5   | Emblem                     | 330      | 226   | 5,252  |
| 6   | Jackets with embroidery    | 33       | 0     | 0      |
| 7   | Headscaves with embroidery | 14       | 0     | 150    |
| 8   | T-shirts with embroidered  | 868      | 418   | 653    |
| 9   | Shirts embroidered         | 224      | 233   | 212    |
| 10  | Vests with embroidery      | 39       | 0     | 0      |
|     | Total                      | 1,734    | 1,176 | 6,602  |

Based on Table 1, it can be seen that there is a change in demand for each different product in the company each period. All of these products are produced by the company using the same facility layout. Layout UD. XYZ can be seen in Figure 1. Any change in demand can affect the flow of material and subsequently material handling costs. To avoid the effects of these changes, excessive costs can be balanced with the right layout and actual material handling costs [8]. From the problems above, it is necessary to redesign the layout with DFLP. The design will then be compared with the SFLP obtained through the first stage of the DFLP model to obtain the best layout design. The method used in redesigning the layout is software CRAFT. CRAFT is an improvement program, this program seeks optimum design by gradually improving the layout. CRAFT evaluates the layout by exchanging the location of the department. Furthermore, CRAFT makes consideration of departmental exchanges for new layouts, and this is done repeatedly until it produces the best layout taking into account the material handling cost [9,10].

2. Research Method

This research was conducted at the company UD. XYZ which is engaged in manufacturing convection and computer embroidery. The object under study is the sequence of the production process and the facility layout on the factory floor. The research began with direct observation in the field. The problem formulation will be determined based on the results of field observations. The results of data collection are used as input for data processing and analysis. The data collected in the form of initial factory layout, distance & frequency of movement between machines, types & number of product demands, operating cost, and others. Dynamic Facility Layout Planning (DFLP) is method to involve the optimal layout based on each different production period [11]. Static Facility Layout Planning (SFLP) is method as the placement facilities in area plan with aim of the determining effective arrangement based on static and some criteria such as size and shape [12]. Based on this data, the existing facility layout was redesigned.
using the Static Facility Layout Planning (SFLP) and Dynamic Facility Layout Planning (DFLP) methods with the help of CRAFT software. Then the total material handling cost is calculated for the initial layout and the layout of the two methods. The method with the smallest total material handling cost is expected to be the best facility layout proposal and can solve company layout problems.

3. Results and Discussion

3.1. Distance Calculation Actual Layout
The results of the calculation of the distance between departments for the layout actual can be seen in Table 2.

3.2. The Calculation of Frequency of Displacement
The recapitulation of the frequency of material transfers between departments can be seen in Table 2.

3.3. The Material Handling Cost Calculation of Actual Layout
Material handling is defined briefly as a material transfer. Material handling has influenced (positively) more people's work than other design work fields [11]. The equation used to calculate material handling costs/meter (OMH) is as follows [12].

\[
OMH/m = \frac{\text{cost}}{d}
\]

Where:
OMH/m = transport cost/meter (IDR/m)
Cost = operating cost/hour (IDR/hour)
d = transport distance/hour (m/hour)
### Table 2. Distance and frequency of material displacement

| From | To  | Distance (m) | Frequency of February | Frequency of March | Frequency of April |
|------|-----|--------------|-----------------------|--------------------|--------------------|
| A    | E   | 7.2          | 159                   | 119                | 175                |
| B    | F   | 5.33         | 15                    | 10                 | 12                 |
| C    | I   | 4.27         | 4                     | 2                  | 6                  |
| C    | K   | 11.15        | 36                    | 24                 | 84                 |
| D    | I   | 1.28         | 8                     | 6                  | 7                  |
| E    | F   | 9.08         | 155                   | 115                | 121                |
| E    | I   | 15.51        | 4                     | 3                  | 53                 |
| F    | G   | 8.65         | 52                    | 36                 | 43                 |
| G    | I   | 9.42         | 52                    | 36                 | 43                 |
| I    | J   | 3.67         | 60                    | 41                 | 102                |
| J    | K   | 5.25         | 60                    | 41                 | 102                |
| K    | L   | 14.44        | 60                    | 41                 | 102                |

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

\[ O\text{MH} = r \times f \times O\text{MH} / m \]  

Where:

- OMH = material handling costs
- r = displacement distance (m)
- f = frequency of displacement

The recapitulation of material handling costs in the actual layout can be seen in Table 3.

| Month     | February  | March  | April  | Total      |
|-----------|-----------|--------|--------|------------|
| Material Handling Cost (IDR) | 138,789.41 | 98,880.42 | 187,339.73 | 425,009.56 |

### 3.4. Redesign of Facility Layout with Static Facility Layout Problems Using Software CRAFT

Since 1983, the CRAFT (Computerized Relative Allocation of Facilities Techniques technique) aims to minimize material handling cost, where material handling cost is defined as product flow, distance, and transportation unit costs. CRAFT was originally presented by Armor and Bufa. [13].

CRAFT is a computerized heuristic algorithm that takes the flow load matrix between departments and transaction costs with block layout representation as input. The block layout can be in the existing layout or for new facilities, any initial layout [14].

The procedure adopted for using CRAFT [15]:

- Calculate the distance between departments.
- Calculate the initial cost of the layout by multiplying from to chart with the cost matrix.
- CRAFT then considers all possible two-way or three-way department exchanges and identifies the best exchanges.
- Update the layout and calculate the centroid of the new department.
- The procedure above is repeated until there is no further reduction in costs.

Proposed block layout with Static Facility Layout Planning (SFLP) shown in Figure 2.
Based on the block layout above, material handling costs which are obtained shown as in Table 4.

**Table 4. Material handling costs of proposed layout on SFLP**

| Month   | February | March       | April       | Total     |
|---------|----------|-------------|-------------|-----------|
| Cost    | 128,586,23 | 91,702,89   | 173,220,89  | 393,510,01 |

3.5. Facility Layout Redesign with Dynamic Facility Layout Problems Using Software CRAFT

Dynamic Facility Layout Problems issues are managing departments for many periods where material flow between departments can change due to diverse market demands to minimize the total amount of costs material handling and cost restructuring [16].

The DFLP formulation is given below.

\[
Min \ DFLP = \sum_{t=1}^{T} SFLP(t) + \sum_{t=1}^{T-1} A_{t(t+1)}
\]  

(3)

Where this the number of periods in the DFLP; at \((t+1)\) is the layout cost between each pair of adjacent periods and \(T\) is the total number of periods across the period horizon [17].

Proposed block layout with the DFLP for February, March, and April is shown in Figure 3.

Recapitulation of material handling cost in the proposed layout with DFLP can be seen in Table 5.

**Table 5. Material handling cost of proposed layout with DFLP**

| Month   | February | March       | April       | Total     |
|---------|----------|-------------|-------------|-----------|
| Cost    | 128,586,23 | 85,887,05   | 128,542,80  | 343,016,08 |

Re-layout costs because location changes can be calculated by equation the following:

\[
Re\text{-}layout \ cost = Cost \ of \ removal \times Distance \ to \ displacement \times number \ of \ units \ transferred
\]  

(4)
Summary of layout cost for March and April can be seen in Table 6.

**Table 6. Summary of relayout cost for March and April**

| Department | Layout Cost for March | Layout Cost for April |
|------------|-----------------------|-----------------------|
| Total (IDR)| 1595.64               | 1073.40               |

3.6. Calculation of Total Costs in Dynamic Facility Layout

Total cost of DFLP can be seen in Table 7.

**Table 7. Total cost of DFLP**

| Month       | February Material Handling Cost (IDR) | March Material Handling Cost (IDR) | March Relayout Cost (IDR) | April Material Handling Cost (IDR) | April Relayout Cost (IDR) | Total Material Handling Cost (IDR) | Total Relayout Cost (IDR) | Total (IDR)   |
|-------------|---------------------------------------|------------------------------------|---------------------------|-----------------------------------|--------------------------|------------------------------------|---------------------------|---------------|
| February    | 128,586.23                            | 85,887.05                          | 128,542.80                | 343,016.08                        |                          |                                    |                           | 345,685.11   |
| March       | 343,016.08                            |                                    | 1,595.63                  | 1,073.40                          |                          |                                    |                           |               |

3.7. Cost Comparison of Actual Layout and Proposed Layout

Cost comparison of actual layout and proposed layout can be seen in Table 8.

**Table 8. Cost comparison of actual layout and proposed layout**

| Actual Layout (IDR) | Proposed Layout with SFLP (IDR) | Cost Difference (IDR) | Percentage | Proposed Layout with DFLP (IDR) | Cost Difference (IDR) | Percentage |
|---------------------|--------------------------------|-----------------------|------------|--------------------------------|-----------------------|------------|
| 425,009.56          | 393,510.01                     | 31,499.56             | 7.41%      | 345,685.11                     | 79,324.45            | 18.66%     |

Based on Table 12, it can be seen that layouts that have the lowest cost are proposal layouts with DFLP. The proposed layout in UD.XYZ with DFLP can be seen in Figure 4.
Figure 4. Proposed layout with DFLP

The proposed layout with DFLP in Figure 5 does not have a cross-movement and has a close distance between departments. In addition, the proposed layout has also considered consumer demand. The proposed layout can reduce material handling costs.

4. Conclusion
Facility layout design in the future is always influenced by changes in process flow and changes in the number of product demands on each time horizon. Dynamic Facility Layout Planning (DFLP) can support these changes and can be developed for more advanced industries. Based on the results of the processing and analysis, it is obtained a material handling cost is IDR 425.009,56. The proposed layout with SFLP has material handling costs of IDR 393,510.01. The proposed layout with DFLP have a total cost amounting to IDR 345,685.11. The proposed layout with SFLP has a lower material handling cost compared to the actual layout of IDR 31,499.56 or a cost reduction of 7.41% and DFLP has a total cost which is lower than the actual layout of IDR 79,324.45 or a reduction in costs of 18.66%. So the layout with DFLP was chosen as the proposed layout design. From the results of the facility layout design with DFLP, it can be seen that the problems of cross-movement and long engine distances can be resolved.

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