Layout design in order to improve efficiency in manufacturing

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Abstract. This research was conducted at the company that produces bobbins and ream type cigarette paper. Problems that found on the production process is the back and forth (back tracking) movement. Back and forth (back tracking) movement extending the total distance moved by the material and increase the total moment of transfer materials thus reducing the efficiency of the transfer of materials in the production process. The purpose of this study is to give design for the layout of production facilities in the company, so that the expected production produced by the company can reach the targets set by the management company. The method used in this research is the Graph-Based Construction and Travel Chart Method. The results of the analysis of the proposed layout with Graph-Based Construction was selected with a total value that is equal to the moment of transfer of 780 758 m / year. This result is better than the actual layout in the amount of 1,021,038.12 meters / year and the results of the method Travel Alternative Chart I of 826,236,60 meters/year, Alternative II of 1,004,433,56 meters / year, and Alternative III for 828,467.12 meters/year. The design layout of Graph-Based Construction material increases the transfer efficiency for 23.53%. With this layout proposal, expected production capacity will be increased along with the shortening of the distance of the displacement that must be passed by the material to be processed.

1. Introduction

The ability of a product company in a competitive market supported by the smooth transfer of material from each of the production department. The layout of the facility is an important element which supports the production of a company. The less effective layout of the facility is resulting the products produced by the company less than the maximum. Therefore, it is necessary to design the layout of the facility every appropriate production department to ensure smooth production. Redesigning the layout of the actions needed to smooth the flow of material in order to increase the production capacity of the company.

Previous research mentioned that the design layout can be intended not as an end result, but the artifacts design that gives insight into the solution space for further exploration, so that the optimal layout can be achieved [1]. Other studies mention that redesigning the layout shows the distance traveled in warehouses can be reduced by more than 2,000 km / month by simply reallocating the shop floor to the different [2]. This shows that there is no perfect layout for companies in the industry and can evolve towards the desired optimum point of the company. Another study discusses the layout such as preparing practical proposals for the design method effective layout of the insights gained from the analysis of the simulation. The study contributes to a critical analysis of the conventional layout [3]. Redesigning the layout has a function to search for the optimal layout of existing layout, as mentioned in previous studies that the optimal design of the layout of equipment in multi-station assembly [4]. The design layout is also
useful for a new concept in considering simultaneously the economic and safety aspects in the design of the facility layout problem [5]. Concerning the layout design, not only for the above purposes, but also to streamline the flow patterns of materials that exist in the company, this jug can be seen on the research conducted, at which the research shows that inventory levels can be set to decline to 74% and the utilization of rooms was reduced to 18.18% [6]. And research shows that redesigning the layout for track and balancing the use of machinery and equipment manufacturing companies [7].

This research attempts to integrate the two methods that already exist in order to find the optimal solution. This is the difference with studies before.

The problem of this research is the distance moved by the material, the arrangement of the machines and departments that have not regularly result in the production targets, so the companies need to redesign the layout that existed at this current time in order to obtain the layout and material removal is more effective. To overcome these problems, it is necessary to redesign the layout by using Graph-Based Construction and Travel Chart. Method Based Construction and Travel Graph Chart is as a process used to design the layout that is supposed to minimize the distance moved and the production process can run properly.

2. Research method

The data collection phase to collect the information and data required in conducting the research. The method used is the method of Graph-Based Construction and Travel Chart.

The graphical method is a method of designing the layout using the proximity graph (adjacency graph) as a liaison between departments or existing facilities, with the aim of obtaining the greatest weight. Procedure graphical method frequently used in building the graphical method is to create a graph closeness done step by step by putting a couple departments that have the greatest weight proximity.

Travel chart is a conventional technique commonly used in factory planning and material handling in a production process. Travel chart useful while a lot of material movements in an area.

Data collection for this method was done in two ways: in the form of field observations observation and interviews and literature useful as supporting information and materials research literature related to plant facility layout problems.

3. Result and analysis

3.1. The Production Level Department Block Layout Drawing

The layout of each department is made in the form of block layout according to size as on the real situation regardless of the alley between departments. Block Initial production floor layout can be seen in Figure 1.

Based on Figure 1. The depiction block layout on the production company created by the original layout of the production in the company in accordance with the size of each department.

3.2. Determination Department Spacing

Distance between departments is calculated using the formula rectilinear distance, where the distance is measured following a line perpendicular. Distance between departments is calculated based on the
distance between the center point of the department. The results of the determination of the coordinates of the location for each department can be seen in Table 1.

| Department | X   | Y   |
|------------|-----|-----|
| A          | 42  | 12.5|
| B          | 52.5| 20.5|
| C          | 46.5| 20.5|
| D          | 32.5| 20.5|
| E          | 21.5| 20.5|
| F          | 16  | 18.75|
| G          | 8.5 | 18.75|
| H          | 2.25| 19.5|
| I          | 3   | 11.75|
| J          | 4.5 | 20.25|
| K          | 6   | 11.75|
| L          | 12.46| 7.9 |

Based on Table 1 shows the coordinates of the location of each department in the company gained from the determination of the midpoint of each department.

Based on Figure 2 shows the coordinates (x, y) location of each department in the company created by making a diagonal line in each box in order to set the midpoint of each department. Distance between departments is calculated using the formula rectilinear distance. For example, the coordinates A (42 ; 12.5) and B (52.5 ; 20.5), so the distance between A and B is:

\[ A-B = |42-52.5| + |12.5-20.5| = 18.5 \text{ m} \]

The calculations for the distance between the other departments also do like the example above. The result of the calculation of the distance between the departments as a whole to the initial layout can be seen in Table 2. Based on Table 2 shows the distance between the parts department at the company's production gained from the withdrawal line from the midpoint of each department.
Table 2. Each Department Distance (dij) (meter)

|       | A   | B   | C   | D   | E   | F   | G   | H   | I   | J   | K   | L   |
|-------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| **A** | 18.50| 12.50| 17.50| 28.50| 32.25| 39.75| 46.75| 39.75| 45.25| 36.75| 34.14|
| **B** | 19.50| 6.00| 20.00| 31.00| 38.25| 45.75| 52.25| 48.25| 55.25| 52.64|
| **C** | 12.50| 6.00| 14.00| 25.00| 32.25| 39.75| 45.25| 39.75| 45.25| 42.25| 49.25| 46.64|
| **D** | 17.50| 20.00| 14.00| 11.00| 18.25| 25.75| 31.25| 28.25| 35.25| 32.64|
| **E** | 28.50| 31.00| 25.00| 14.75| 14.75| 20.25| 27.25| 17.25| 24.25| 21.64|
| **F** | 32.25| 38.25| 32.25| 18.25| 7.25| 14.75| 20.25| 27.25| 17.25| 24.25|
| **G** | 39.75| 45.75| 39.75| 25.75| 7.25| 14.75| 20.25| 17.25| 24.25| 21.64|
| **H** | 46.75| 51.25| 45.25| 31.25| 20.25| 14.50| 14.50| 20.00| 13.00| 17.00|
| **I** | 39.75| 58.25| 52.50| 38.25| 27.25| 20.00| 12.50| 8.50| 10.00| 3.00|
| **J** | 45.25| 48.25| 42.25| 28.25| 17.25| 13.00| 12.50| 8.50| 10.00| 3.00|
| **K** | 36.75| 55.25| 49.25| 42.25| 17.00| 9.50| 11.50| 3.00| 10.00| 10.00|
| **L** | 34.14| 52.64| 46.54| 21.64| 14.39| 14.81| 21.81| 13.31| 20.31| 10.31|

3.3. Determination of Interdepartmental Material Transfer Frequency

Frequency displacement of material needs to be calculated to get a moment of displacement. Frequency displacement of materials on the production floor is obtained through the amount of flow of material displacement occurs. Data transfer frequency data dependent material production volume and capacity transfer equipment used. Volume production of the company in the year 3,098 is a jumbo roll of cigarette paper. The calculation of the frequency of material movements can be seen in Table 3.

Table 3. Material Transfer Frequence

| No | Origin Department | Destination Department | Production (unit/year) | Transport Capacity | Frequency of material transfer |
|----|-------------------|------------------------|-----------------------|-------------------|-----------------------------|
| 1  | A                 | B                      | 3,098                 | 1                 | 3,098                       |
| 2  | B                 | C                      | 3,098                 | 1                 | 3,098                       |
| 3  | C                 | D                      | 3,098                 | 1                 | 3,098                       |
| 4  | D                 | E                      | 3,098                 | 1                 | 3,098                       |
| 5  | E                 | L                      | 3,098                 | 1                 | 3,098                       |
| 6  | E                 | F                      | 3,098                 | 1                 | 3,098                       |
| 7  | F                 | G                      | 3,098                 | 1                 | 3,098                       |
| 8  | L                 | F                      | 3,098                 | 1                 | 3,098                       |
| 9  | G                 | H                      | 3,098                 | 1                 | 3,098                       |
| 10 | H                 | J                      | 3,098                 | 2                 | 6,196                       |
| 11 | G                 | I                      | 3,098                 | 1                 | 3,098                       |
| 12 | I                 | K                      | 3,098                 | 2                 | 6,196                       |
| 13 | J                 | L                      | 3,098                 | 2                 | 6,196                       |
| 14 | K                 | L                      | 3,098                 | 2                 | 6,196                       |
| 15 | L                 | A                      | 3,098                 | 4                 | 12,392                      |
Based on Table 3 shows the frequency of material movements on the company by multiplying the volume of production with a payload capacity.

3.4. Calculation of Total Moment Displacement at the Basic Layout

Total moment of displacements on the production floor can be determined by multiplying the frequency of movement of material from one department to another with the distance between related departments. Example calculation of the moment of transfer to the transfer material from department A to department B are as follows:

1. Frequency displacement from A to B = 3,098 times
2. Distance moved from A to B = 18.50 meters
3. Then the moment of transition from A to B $Z_{A-B} = 3,098 \times 18.50 \text{ meters} = 57,313 \text{ displacement meter/year}$
4. Complete calculation for any displacement that occurs on the shop floor can be seen in Table 4.

| No | Origin Department | Destination Department | Frequency of material transfer $(f_{ij})$ (unit/year) | Department Distance (m) | Moment material transfer (m/year) |
|----|-------------------|------------------------|---------------------------------|------------------------|---------------------------------|
| 1  | A                 | B                      | 3,098                           | 18.50                  | 57,313.00                       |
| 2  | B                 | C                      | 3,098                           | 6.00                   | 18,588.00                       |
| 3  | C                 | D                      | 3,098                           | 14.00                  | 43,372.00                       |
| 4  | D                 | E                      | 3,098                           | 11.00                  | 34,078.00                       |
| 5  | E                 | L                      | 3,098                           | 21.64                  | 67,040.72                       |
| 6  | E                 | F                      | 3,098                           | 7.25                   | 22,460.50                       |
| 7  | F                 | G                      | 3,098                           | 7.50                   | 23,235.00                       |
| 8  | L                 | F                      | 3,098                           | 14.39                  | 44,580.22                       |
| 9  | G                 | H                      | 3,098                           | 7.00                   | 21,686.00                       |
| 10 | H                 | J                      | 6,196                           | 3.00                   | 18,588.00                       |
| 11 | G                 | I                      | 3,098                           | 12.50                  | 38,725.00                       |
| 12 | I                 | K                      | 6,196                           | 3.00                   | 18,588.00                       |
| 13 | J                 | L                      | 6,196                           | 20.31                  | 125,840.76                      |
| 14 | K                 | L                      | 6,196                           | 10.31                  | 63,880.76                       |
| 15 | L                 | A                      | 12,392                          | 34.14                  | 423,062.88                      |

| JUMLAH | 1,021,038.84 |

Based on Table 4. The total moment of displacements obtained by multiplying the frequency of movement of material per year that occur with departments within the company.

3.5. Proposed Layout Design

The design layout of the proposal made to each work station first, then after every station has designed the layout of the proposed use of the two methods. Here is an explanation of the process of designing the layout of the proposed using Graph-Based Construction and Travel Chart.

3.5.1 Proposed Layout Design Method Based Graph Construction

The design of the proposed layout using Graph-Based Construction is done by making from to chart that will be designed layout proposal, after it been the greatest value that exist on the map of flights. From to chart can be the value of the degree of proximity of each operation. After selecting one pair of operations that have the greatest weight value then the next step choose the operation that has the greatest weight with two operations that have been previously selected. Here is an example of the work of designing the
layout of the proposed using Graph-Based Construction. From moment to chart based transfer between departments can be seen in Table 5.

Table 5. From To Chart Moment Displacement

| From To Chart | Moment | Displacement |
|---------------|--------|--------------|
| L             | A      |              |

From Table 5 above were chosen department of L and A, because it has the greatest weight, namely 423,062.88. Ministry of L and A inserted into the first iteration. Figure iteration 1 Graph Based Construction methods can be seen in Figure 3.

Figure 3. 1st Iteration Graph Based Construction Method

The consideration for selecting the third department can be seen in Table 6.

Table 6. Consideration in Third Department Choosing

| Department | L  | A   | Total    | Notes |
|------------|----|-----|----------|-------|
| B          |    | 57,313 | 57,313   |       |
| C          |    | -    | -        |       |
| D          |    | -    | -        |       |
| E          |    | 67,040.72 | 67,040.72 |       |
| F          |    | 44,580.22 | 44,580.22 |       |
| G          |    | -    | -        |       |
| H          |    | -    | -        |       |
| I          |    | -    | -        |       |
| J          |    | 125,840.76 | 125,840.76 | CHOSEN |
| K          | 63,880.76 | -    | 63,880.76 |       |

Based on Table 6. obtained weighting to choose the department into three companies were selected based on the distance the longest distance from the department selected. A department has the largest weight value so that the department of J into the graph Graph-Based Construction methods like Figure 4.
Figure 4. 2nd Iteration Graph Based Construction Method

Based on Figure 4, didapatlah iteration 2 Graph Based Construction methods are selected based on the longest distance the department then created nodes and connected by arc. The same step conducted on all operations and every department, after doing the design work of the department then it obtained the final results of Graph-Based Construction Methods shown at Figure 5.

Figure 5. Final Result of Graph Based Construction Method

Based on Figure 5 shows the final results of Graph-Based Construction methods derived from iterations are made continuously until all departments are covered. Based on the allocation sequence and charts last closeness, it can be made several alternative design layout of new production floor, as described as follows: Block layout design first alternative method Graph-Based Construction can be seen in Figure 6.

Figure 6. Graph-Based Construction 1st Alternative Block Layout

Based on Figure 6. Above shows the block layout Graph-Based Alternative I consider the moment of transfer of Construction made the shortest. Block layout alternative designs II with Graph-Based Construction methods can be seen in Figure 7.
Figure 7. 2\textsuperscript{nd} Alternative Graph-Based Construction Block Layout

Based on Figure 7. Above shows the layout block Alternative II Graph-Based Construction made considering the displacement shortest moment. Block layout alternative design III with Graph-Based Construction methods can be seen in Figure 8.

Figure 8. 3\textsuperscript{rd} Alternative Graph-Based Construction Block Layout

Based on Figure 8. The above shows the block layout Graph-Based Alternative Construction III was made considering the displacement shortest moment.

3.5.2. Redesign Proposed Layout by Using Travel Chart Method

Chart Travel is made using matrix model, where the location department is randomly (for the first time) and thereafter made moments displacement analysis. Based on the method of processing the travel chart, then it can be made several alternative design layout of new production floor, as described as follows: Block layout design first alternative method Chart Traveling can be seen in Figure 9.

Figure 9. 1\textsuperscript{st} Alternative Travel Chart Block Layout
Based on Figure 9. The above shows the block Layout Alternative I Travel Chart by putting departments have the highest correlation as the center and other departments made arbitrarily by the close relationship between his department. Block layout alternative design Travel Chart II method can be seen in Figure 10.

![Figure 10. 2nd Alternative Travel Chart Block Layout](image)

Based on the above Figure 10 shows the block Alternative II Travel Chart Layout by putting a department that has the highest correlation as the center and other departments made arbitrarily by the close relationship between his department. Block layout design alternatives Chart Travel III method can be seen in Figure 11.

![Figure 11. 3rd Alternative Travel Chart Block Layout](image)

Based on Figure 11 above shows the block Layout Alternative Chart Travel III by putting a department that has the highest correlation as the center and other departments made arbitrarily by the close relationship between his department. As for the comparison between each alternative displacement moments of graph-based methods of construction and any alternative method of travel chart can be seen in Table 7.

|            | Graph Based Construction | Travel Chart |
|------------|--------------------------|--------------|
| Moment Material Transfer (meter/year) | I | II | III | I | II | III |
| 780,758.00 | 895,817.70 | 807,958.40 | 826,236.60 | 1,004,433.56 | 828,467.20 |

Based on Table 7. obtained from the calculation of the total transfer between departments within moments of each alternative layout of each method.
4. Conclusion and discussion
The layout of the selected proposals is having a total moment of material displacement is smaller than the initial layout is the layout of the first alternative method of Graph-Based Construction material movements with a total moment of 780,758 meters/year with an efficiency of 23.53%.

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