Redesign of Facilities Layout Using Systematic Layout Planning (SLP) on Manufacturing Company: A Case Study

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Abstract. An effective facility planning can significantly reduce the operational costs of companies. The facility layout problem is relating to location of objects on a given site and the material flow between these objects. The study conducted in a Hard Disk Drive (HDD) manufacturer. In the company, there are several obstacles was found in the Brushing Room. One of the causes of these obstacles can be marked by the alternating flow during the production process of the Tressel parts, one of the products of the company. To correct the problem of the layout of the existing facilities, it is necessary to redesign the layout of the facilities based on the production process flow. The methods used was the Systematic Layout Planning (SLP) method to minimize costs material handling resulting from the production process. Layout suggested using the SLP method succeeded in reducing the material handling costs (OMH) of the production process flow of the Tressel. This can result in savings in the company's material handling costs, from IDR 5,377,415 per month to IDR 2,971,717 after the improvement were conducted. OMH is reduced by IDR 2,405,698 in each month and resulting in savings of 44.7%.

1. Introduction
In the growing market globalization, where customer demands are changing continuously, the enterprises have to focus on cost reduction and profitability. This research study is very important and actual, because the cost reduction and the improvement of productivity are very important goals of all manufacturing companies. Within production, the resources (raw materials, energies, humans, machines, equipment and other facilities) are always limited. It is very important at the manufacturing companies to produce cost effective products which can be realized by a minimized production cost with higher effectiveness.

The optimal facility layout is an effective tool in cost reduction by enhancing the productivity. Facility layout design involves a systematic physical arrangement of different departments, workstations, machines, equipment, storage areas and common areas in a manufacturing company. There are two methods for layout improvement. The first is the re-routing of material flow in a given facility that can improve the efficiency of material movement. When re-routing is not efficient, the other way is the re-layout.

After observing, the company experienced several obstacles in the irregular layout of company facilities, one of which was found in the Brushing Room. In this room, there are obstacles in the form
of waste in the company. Waste that is meant is the output generated from the production process is not by the plan (not optimum). This can affect the next production process and will affect the long-term sustainability of the company. So that the operator or company employees must work overtime (overtime) to overcome the constraints that exist [1].

One of the causes of this waste can be marked by the alternating flow during the production process of the Tressel parts. The product undergoes an alternating production flow from the brushing machine to the checker area carry out a process of quality control. Products that still have defects will be returned to the brushing machine for processes, sorting and reworking so on until the product has no defects and meets established quality standards. Tressel products have the highest sales data for the company. The number of requests for monthly order parts is 65,000. Sales per month for Tressel products can contribute 40% of the total sales made by the company. Besides, the high cost of material handling during the production process is also an obstacle in the area brushing this. So, when there is an alternating flow in the production process, it can produce high OMH [2]. The Material Handling System is carried out to improve the efficiency of material transfer from one station to another. Besides, the equipment used to move material from one station to another (material handling equipment) must also be considered in planning the layout of company facilities [3]. Material Handling Equipment is equipment related to the movement, storage, control and protection of materials, goods and products throughout the manufacturing, distribution, consumption and disposal processes. Material handling equipment can be in the form of human power, conveyor belts, stroller, and others. The purpose of making planning material handling is to increase production capacity, reduce costs incurred, and improve the production flow of the company. Losses that may be experienced by the company if it does not make the appropriate layout of facilities will have an impact in the long run. Besides, operators or workers will get tired more quickly when working in long distances, alternating production flow, and high workload.

Based on previous research, a method were chosen to improve the layout of the facilities at the company, namely the Systematic Layout Planning (SLP) method to minimize costs material handling resulting from the production process.

2. Literature Review

Previous research related to this research can be seen in Table 1. Reference [4] conducted a feasibility study for redesigning of production facility. The research aims to minimized production cost and higher effectiveness of the company. The method used in this study are Graph and Craft method for minimizing material handling costs. The results of the analysis of the existing layout show that the displacement moment per year is 642,337.5 m. From the moment of displacement it can be analyzed that the backward flow owned is 20.47%, and the annual OMH is IDR 16,251,287.5. Alternative layouts produced by the graphical method provide improvement in the moment of displacement, which is 546,000 manually. Owned backward flow is reduced to 0%, and OMH per year is IDR 14,574,448.44. While the alternative layout of the CRAFT method with the help of WinQSB 2.0 software results in 642,337.5 m of displacement moment per year, so that the percent of backward flow is 14.84% and OMH obtained is IDR 15,433,586.79 per year. From these results it can be determined that the chosen layout is an alternative graphic layout, because it provides the largest OMH reduction of IDR 1,676,839.06 per year.

Reference [5] conducted a feasibility study for redesigning of production facility. The research aims to minimized production cost of the company. The method used in this study are SLP method for minimizing material handling costs. The new plant layout has been designed and compared with existing plant layout. The new plant layout shows that the distance and overall cost of material flow from stores to dispatch area are significantly decreased. The implementation of proposed model will help in the overall improvement of production performance of the engine reconditioning unit of the corporation.

Reference [6] conducted a feasibility study to make a layout that fits the order of process flow by designing through the Bloclplan-90 application. The study was conducted in November 2018 until
February 2019. The Blocplan method is one of an easy computer operating the system by using manually entering facility data. The data needed is in the form of a map of the operation process, a linkage diagram of activities. The results of the initial layout data processing resulted in R-Score 0.78 and the proposed improvement with automatic search resulted in R-Score 0.98. The design of the proposed improvement is more optimal with the value of R-Score approaching the value of 1(one). Changes in the layout of the facility occur in squash which is closer to mixing and weighing materials and oven facilities close to the finished product.

**Table 1. The Comparison among Proposed Research and Other Published Research**

| Researcher            | Title                                                                 | Research Method                              | Results                                                                 |
|-----------------------|----------------------------------------------------------------------|----------------------------------------------|------------------------------------------------------------------------|
| Barnwal and Dharmadhikari (2016) | Optimization of Plant Layout Using SLP Method | Systematic Layout Planning (SLP) Method | From these results it can be determined that the chosen layout is an alternative graphic layout, because it provides the largest OMH reduction of IDR 1,676,839.06 per year. |
| Ningtyas et al. (2015) | Redesign of the Production Facility Layout with Graph and CRAFT Methods for Minimization of Material Handling Costs | Graph and CRAFT Methods | The new plant layout shows that the distance and overall cost of material flow from stores to dispatch area are significantly decreased. The implementation of proposed model will help in the overall improvement of production performance of the engine reconditioning unit of the corporation. |
| Aini et al. (2019)    | Proposed Improvement of Layout Production Facilities for Pastries at PT. Surya Indah Food Multirasa | Blocplan Method                              | The results of the initial layout data processing resulted in R-Score 0.78 and the proposed improvement with automatic search resulted in R-Score 0.98. The design of the proposed improvement is more optimal with the value of R-Score approaching the value of 1(one). Changes in the layout of the facility occur in squash which is closer to mixing and weighing materials and oven facilities close to the finished product. |
Reference [7] aims to find out how big the role of facility layout design in cutting the distance of material transfer and pressing the cost of material handling. The method used in this research is Systematic Layout Planning (SLP) approach, which is comparing the distance of material transfer between initial layout with proposed layout. The results of this study indicate that the distance of the material flow path on the production floor with proposed layout changed to 71.7 meters, with material handling cost per meter reduced from IDR 1,105,954 to IDR 712,402 or decrease as much as 35%. Based on the results of the research, the layout of the proposal is considered more effective and efficient because it can reduce the distance of material transfer and reduce the cost of material handling on the packing/shipping floor.

The goal of this study is to minimize production cost and maximize higher effectiveness by redesigning of facilities layout using systematic layout planning (SLP) method for minimizing material handling costs.

3. Research Method

3.1 Research Framework

Data collection is done through interview with the company, information from company references, books and results observation to the field. In this study the data information will be needed regarding research objects that are useful as material in problem solving that has been formulated at the outset, the data needed as the following is the flow of the material removal process, material handling costs, floor areapacking / shipping and in the company.

In this research, the discussion will be discussed based on the results of calculations and studies book as material for analysis of results will be proposed or as an evaluation material research, points to be discussed based on the results of the study as follows:

a. Discussion of the results of the calculation of the distance of the track in the initial layout with the proposed layout.

b. Discussion on material handling layout costs beginning with a proposal layout.

The stages of this research can be seen in Figure 1. This research starts with initial observation and literature review, then identifies the problem, then determines the objectives and benefits of the research, after determining the objectives and benefits of the research, the next step is collecting data containing the company initial layout, production process flowchart, operation process chart, calculation of available area, data on machine characteristics and production area, distance between work stations, and material handling activities, the next step is processing initial layout data and design proposal with systematic layout planning (SLP), then comparing the performance of the initial layout with alternative layouts.

To correct the problem of the layout of the existing facilities in the company, it is necessary to redesign the layout of the facilities based on the production process flow. There are several methods for redesigning the layout of facilities. As has been done by reference [5], who used the Systematic Layout Planning (SLP) method to redesign the facility layout of an automobile industry.
3.2 Systematic Layout Planning (SLP) Method

According Reference [8] SLP is an approach to planning layout by step systematic approach. The consideration used for planning must be based on data on production activities, both current and future (predicted).

According Reference [9], SLP consists of three stages. The first stage is analysis, namely material flow analysis, activity analysis, activity relationship diagrams, space requirements considerations and available space. The second stage is research, starting from the planning of room relationship diagrams to alternative layout designs. While the third stage is the selection process by evaluating alternative layout that has been designed. The design of the alternative layout with the SLP method is prepared based on the level of closeness that has been obtained from the Priority Scale Table (TSP) and Activity Relationship Diagram (ARD).

The stages of the method formation procedure Systematic Layout Planning (SLP):
1. Data collection and flow analysis material (flow of material), for analyze quantitative measurements for every movement of material movement in between departments or departments operational activities. Usually maps or diagrams are often used as follows:
   a. Process flow map.
   b. From to chart.
   c. Activity relationship map.
2. Analyzing the relationship of activity, to get or to know the costs removal of material and nature quantitative is more analytical Qualitatively in layout design is called Activity Relationship Chart (ARC).
3. Making room relationship diagrams.
4. Calculating the need for area area.
5. Formation of alternative block layouts

4. Results and Discussion
Tressel is one of the superior parts produced by Hard Disk Drive (HDD) manufacturer with a total monthly demand of 455,000 units. This part has the highest demand compared to nine other products in the company. Tressel’s functions as one of the complementary components for storage data on a Hard Disk Drive (HDD). Tressel has a length of 6.5 cm, width of 3.3 cm, and thickness of 1.9 cm. Tressel has been illustrated in figure 1.

![Tressel](image1.jpg)

Figure 1. Tressel

4.1 Initial Layout
This subsection contains the initial layout of the brushing area in the company. The initial layout consists of one floor with a spacious room that is equal to ± 761.27 m2. There are several stations grouped into 15 areas, namely storage area before deburring, storage area after checking, deburring area 1, deburring area 2, deburring area 3, deburring area 4, deburring area 5, checker area 1, storage area 1 for defects, brushing machine area, checker area 2, visual area, QA area, and final storage area as shown in Figure 2 available with 2D image and 3D image.
In this subsection will describes the overall production process flow and the production process flow in brushing area at the company. The flowchart of entire production process can be explained as shown in Figure 3 and Flowchart of the production process in brushing area can be explained as shown in Figure 4.

Flowchart of the production process in the brushing area starts from the distribution of raw materials from the warehouse, then pre-cut, then enters the machining area in Blocks A and C which consists of three stages, namely the processes P1, P2, and P3, after which the product enters the process washing line in Block D, then the brushing process in Block D, then entering the chemical polishing area in Block B, then entering the VMI area in Block D, then entering the FVMI area in Block D, then entering the store area in Block A, then the last process is shipment.

**Figure 3. Flowchart of the Overall Tressel Production Process**
Flowchart Production Process Brushing Area of Tressel starts from E Block after machined (incoming pre-wash), after that enters the deburring process, then the buy-off checker process is carried out, if found defective then sort and rework are carried out, if no defects are found then proceed to the area brushing, after going through brushing, the quality control process is carried out, if there is a defect then a sort and rework process is carried out, if there is no defect then proceed to the chemical polishing process.

Then, we need to discuss the size and number of machines available at each station in the brushing area at the company. The size and number of machines in the company are shown in Table 2. In accordance with the table, there are two types of machines in the production process in the company’s brushing area, namely machine for brushing which amounts to three machines and one machine for rework.

Next, Determining the distance done by rectilinear distance method is the calculation of the actual distance experienced by the material by drawing a perpendicular line to the work station. The distance between these areas is the distance of displacement needed by the material. The method used in calculating the distance between stations is the rectilinear method. According to Heragu (2006), distance calculation using the rectilinear method is to use the amount of distance travelled on each axis. The distance between work areas as shown in Table 3.

![Figure 4. Flowchart Production Process Brushing Area of Tressel](image)

| Description                  | Machine     | Quantity | Size (length x width) m |
|------------------------------|-------------|----------|-------------------------|
| Machine for Brushing         | Machine F12 | 1        | 2 x 01.8                |
| Machine for Brushing         | Machine F13 | 1        | 2 x 01.8                |
| Machine for Brushing         | Machine F14 | 1        | 2 x 01.8                |
| Machine for Rework Contam    | Contam Machine | 1         | 1 x 0.5                |

Based on the data above, It can be seen the distance from each work area. In the brushing area of the company, has 15 areas of production namely storage area before deburring, storage area after...
checking, deburring area 1, deburring area 2, deburring area 3, deburring area 4, deburring area 5, white contam area, checker area 1, storage area for defect, brushing machine area, checker area 2, visual area, QA area and final storage area.

It can be seen the distance from each work area. In the brushing area of the company, has 15 areas of production. With the highest distance between stations, which is between the QA area and the storage area for the effect.

Table 3. Distance Data between Work Stations Using Rectilinear Method.

| Area                        | Symbol | From | To  | Distance (m) |
|-----------------------------|--------|------|-----|--------------|
| Storage area before deburring | A      | A    | C   | 14           |
| Storage area after checking | B      | A    | D   | 12.74        |
| Deburring area 1            | C      | A    | E   | 11.48        |
| Deburring area 2            | D      | A    | F   | 10.22        |
| Deburring area 3            | E      | A    | G   | 8.96         |
| Deburring area 4            | F      | C    | I   | 1.94         |
| Deburring area 5            | G      | D    | I   | 1.94         |
| White contam area           | H      | E    | I   | 1.94         |
| Checker area 1              | I      | F    | I   | 1.94         |
| Storage area for defect     | J      | G    | I   | 1.94         |
| Brushing machine area       | K      | I    | H   | 1.39         |
| Checker area 2              | L      | H    | I   | 1.39         |
| Visual area                 | M      | I    | B   | 4.5          |
| QA area                     | N      | B    | K   | 3.6          |
| Final Storage Area          | O      | K    | L   | 15.5         |
|                             |        | L    | M   | 2.5          |
|                             |        | M    | N   | 2            |
|                             |        | N    | O   | 10.55        |
|                             |        | N    | J   | 53           |
| Total                       |        |      |     | 161.53       |

Material handling costs is a cost incurred due to material activities from one machine to another or from one department to another, the amount of which is determined to a certain extent. The material handling costs per month can be determined by data on labor costs per month, the frequency of material handling, total workers, and the total distance of material handling. The initial data calculation of material handling costs as shown in Table 4.

Table 4. Data The calculation of Total Cost OMH Monthly

| Data                                      | Total            |
|-------------------------------------------|------------------|
| Number of Workers                         | 75 workers       |
| Total movement frequency                  | 75 times         |
| Total working time a day                  | 720 minutes      |
| Sallary                                   | IDR 3,700,000.00 |
| % Material handling cost(the division of time the operator walks with the number of hours worked a day) | 42% |

Brushing area at the company has 75 workers. With a monthly salary is IDR 3,700,000.00, brushing area with the initial layout produces 42% material handling costs, which is obtained from the distribution of the length of time the operator walks with the number of hours worked a day. Following are the results OMH calculation with the initial layout of the company as shown in Table 5.
Table 5. Calculation of the Total Cost of OMH Each Month in the Initial Layout

| From | To | Component    | Lifting Equipment | Frequency (times) | Distance (m) | Frequency x Distance (m) | OMH / meter (IDR) | Total (IDR) |
|------|----|--------------|-------------------|------------------|--------------|-------------------------|------------------|-------------|
| A    | C  | Part Tressel | Human             | 1056             | 14           | 14784                   | 1.843.833.333    | 272,592     |
| A    | D  | Part Tressel | Human             | 1056             | 12.74        | 13453.4                 | 1.843.833.333    | 248,059     |
| A    | E  | Part Tressel | Human             | 1056             | 11.48        | 12122.9                 | 1.843.833.333    | 223,526     |
| A    | F  | Part Tressel | Human             | 1056             | 10.22        | 10792.3                 | 1.843.833.333    | 198,992     |
| A    | G  | Part Tressel | Human             | 1056             | 8.96         | 9461.76                 | 1.843.833.333    | 174,459     |
| C    | I  | Part Tressel | Human             | 1056             | 1.94         | 2048.64                 | 1.843.833.333    | 37,774      |
| D    | I  | Part Tressel | Human             | 1056             | 1.94         | 2048.64                 | 1.843.833.333    | 37,774      |
| E    | I  | Part Tressel | Human             | 1056             | 1.94         | 2048.64                 | 1.843.833.333    | 37,774      |
| F    | I  | Part Tressel | Human             | 1056             | 1.94         | 2048.64                 | 1.843.833.333    | 37,774      |
| G    | I  | Part Tressel | Human             | 1056             | 1.94         | 2048.64                 | 1.843.833.333    | 37,774      |
| I    | H  | Tressel Part | Human             | 5280             | 1.39         | 7339.2                  | 1.843.833.333    | 135,323     |
| H    | I  | Tressel Part | Human             | 5280             | 1.39         | 7339.2                  | 1.843.833.333    | 135,323     |
| I    | B  | Part Tressel | Human             | 5280             | 4.5          | 23760                   | 1.843.833.333    | 438,095     |
| B    | K  | Part Tressel | Human             | 5280             | 3.6          | 19008                   | 1.843.833.333    | 350,476     |
| K    | L  | Part Tressel | Human             | 5280             | 15.5         | 81840                   | 1.843.833.333    | 1,508,993   |
| L    | M  | Part Tressel | Human             | 5280             | 2.5          | 13200                   | 1.843.833.333    | 243,386     |
| M    | N  | Part Tressel | Human             | 5280             | 2            | 10560                   | 1.843.833.333    | 194,709     |
| N    | O  | Part Tressel | Human             | 5280             | 10.55        | 55704                   | 1.843.833.333    | 1,027,089   |
| N    | J  | Part Tressel | Human             | 38.4             | 53           | 2035.2                  | 1.843.833.333    | 37,526      |
|     |    | TOTAL        |                   |                  | 161.53       | 291643                  | 3.503.283.333    | 5,377,415   |

So based on the table 5, it can be seen if the cost of material costs handling in a month for making Tressel is IDR 5,377,415 the total cost of material handling can be known from the sum of the activities carried out by workers or operators, especially those who experience location shifts, for example, when carrying a train part to the checker area 2 which has a material handling fee for one month of IDR 1,508,993.

From to Chart (FTC) is a common conventional technique used for layout planning plant and material transfer in a production process. Basically from to chart is an adaptation of the “Mileage Chart” which is generally found on a travel map. The numbers contained in an FTC will indicate the total weight of the load to be moved, the frequency and distance of material movement, volume, or combinations of these factors. The details of from to chart can be shown in Table 6.

4.2 Alternative Layout Design

In accordance with the Priority Scale Table (TSP), a number of work stations were moved, such as: storage area before deburring to the work station location closer to the deburring area 1, 2, 3, 4, and 5, moving the storage area after checking closer to brushing machine, moving storage area after checking closer to checking area 1, moving checking area 2 closer to brushing machine, moving storage area for defect closer to QA area. The removal of this work station does not change the size of the existing room, but only relocates the work station as shown in Figure 5.
In this subsection explains about the calculation of the material handling costs of alternative layout at the company. Based on the results of the alternative layout, it can be calculated the amount of total material handling costs per month is IDR 2,971,717. Which means the results of improvements to the SLP method resulted in savings material handling costs of 44.7%. So, the layout suggested using the SLP method succeeded in reducing the material handling costs (OMH) of the production process flow of Tressel. This sub section explains the investment that must be spent by the company in realizing alternative solutions to improve the company’s layout. The investment needed in building a new layout as shown in table 8.
Table 7. ARC Worksheet

| From | To  | Component | Lifting Equipment | Frequency (times) | Distance (m) | Frequency x Distance (m) | OMH/meter (IDR) | Total OMH / month (IDR) |
|------|-----|-----------|-------------------|------------------|--------------|--------------------------|-----------------|-------------------------|
| A    | C   | Part Tressel | Human            | 1056             | 1.3          | 1372.8                   | 184,383.333    | 25,312                  |
| A    | D   | Part Tressel | Human            | 1056             | 1.44         | 1520.64                  | 184,383.333    | 28,038                  |
| A    | E   | Part Tressel | Human            | 1056             | 1.89         | 1995.84                  | 184,383.333    | 36,800                  |
| A    | F   | Part Tressel | Human            | 1056             | 1.9          | 2006.4                   | 184,383.333    | 36,995                  |
| A    | G   | Part Tressel | Human            | 1056             | 2            | 2112                     | 18,4383333     | 38,942                  |
| C    | I   | Part Tressel | Human            | 1056             | 2.1          | 2217.6                   | 184,383.333    | 40,889                  |
| D    | I   | Part Tressel | Human            | 1056             | 1.92         | 2027.52                  | 184,383.333    | 37,384                  |
| E    | I   | Part Tressel | Human            | 1056             | 1.81         | 1911.36                  | 184,383.333    | 35,242                  |
| F    | I   | Part Tressel | Human            | 1056             | 1.22         | 1288.32                  | 184,383.333    | 23,754                  |
| G    | I   | Part Tressel | Human            | 1056             | 1.1          | 1161.6                   | 184,383.333    | 21,418                  |
| I    | H   | Part Tressel | Human            | 5280             | 1.52         | 8025.6                   | 184,383.333    | 147,979                 |
| H    | I   | Part Tressel | Human            | 5280             | 1.52         | 8025.6                   | 184,383.333    | 147,979                 |
| I    | B   | Part Tressel | Human            | 5280             | 2.3          | 12144                    | 184,383.333    | 223,915                 |
| B    | K   | Part Tressel | Human            | 5280             | 3            | 15840                    | 184,383.333    | 292,063                 |
| K    | L   | Part Tressel | Human            | 5280             | 5.4          | 28512                    | 184,383.333    | 525,714                 |
| L    | M   | Part Tressel | Human            | 5280             | 4.5          | 23760                    | 184,383.333    | 438,095                 |
| M    | N   | Part Tressel | Human            | 5280             | 3.6          | 19008                    | 184,383.333    | 350,476                 |
| N    | O   | Part Tressel | Human            | 5280             | 5.3          | 27984                    | 184,383.333    | 515,978                 |
| N    | J   | Part Tressel | Human            | 38.4             | 6.7          | 257.28                   | 184,383.333    | 4,744                   |
|      |     |            |                   |                  |              |                          |                 | TOTAL                   |
|      |     |            |                   |                  |              |                          |                 | 2,971,717               |

Table 8. Investment in Alternative Layout

| No. | Investment   | Description | Cost         | Quantity | Total      |
|-----|--------------|-------------|--------------|----------|------------|
| 1   | Material Costs | Hand Truck | IDR 315,000.00 | 2        | IDR 630,000 |
| 2   | Workers      |             | IDR 323,750.00 | 5        | IDR 647,500 |
|     | Total        |             | IDR 1,277,500 |          |            |

Based on the results of the table 8, it can be calculated the amount of total investment in alternative layout is IDR 1,277,500.
5. Conclusion

Based on the results of data processing and analysis that have been carried out previously, it can be concluded that the Layout suggested using the SLP method succeeded in reducing the material handling costs (OMH) of the production process flow of Tressel. The results of improvements to the SLP method resulted in savings material handling costs of 44.7%. For further research that discusses regarding the design of layout proposals, it is also necessary to do the cost calculation others that might arise if changes done in layout of departments/facilities already available. This needs to be done so the implications of similar research can be more seen. For more accurate results in improving the layout of facilities at the company, it is necessary to pay attention not only on one product but to the production process flow of all products produced by the company.

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