Layout Design in Group Technology Using Cellular Manufacturing System

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Abstract. The facility layout problem is one of the design problems involving the assignment of facilities (e.g., machines, departments) to planar region (e.g., a plant) so as to achieve the objectives such as to minimize the cost of projected interaction between facilities or to maximize the closeness rating, etc. Layout has a significant role on the efficiency of manufacturing systems. This research use Cellular Manufacturing System to solve the layout design problem. Selection of this method because Cellular Manufacturing is an flexible alternative solution for complex and automated manufacture tools. Component movement and total distance can be reduced. Cellular manufacturing system have a philosophy that similar component identified and grouped to take advantage from similarity. By study result, manufacture cell grouping reduce total distance from 411.51 m to 335.14 m.

Keywords: Layout, Group Technology, Cellular Manufacturing System, Rank Order Clustering

1. Introduction

The layout is a major foundation in the industrial world, the layout of factories or facilities can be defined as the procedure for managing factory facilities to support the smooth production process [1]. The arrangement will try to utilize the area for the placement of machinery and supporting facilities, the smooth movement of material movements, storage of materials, work personnel and so on. In the factory layout there are two things that are regulated, namely the machine arrangement (machine layout), namely the arrangement of all machines and facilities needed for the production process in each department of the factory and the department setting (department layout), namely the arrangement of parts and their relationship with one the others in the factory concerned. A well-planned plant layout will also determine the efficiency and smoothness of the process in the industry. The main objective in plant layout design is basically to increase productivity and minimize total costs such as material moving costs, production costs, maintenance costs, storage costs.

The material handling system is basically designed in conjunction with the facility layout. The material transfer system focuses on the procedure for transferring material, both from the type of material transfer tool and the removal procedure [2][3]. Material transfer system can be defined as a mechanism for managing material transfer by considering economic, ergonomic, and technical aspects. The material transfer system is part of the production control system [4]. The removal system is an effort to reduce lead time. Displacement of material cannot be avoided even though it is a waste. But by designing a good material transfer system we can optimize it. One of the most important things is the selection of appropriate material removal equipment.
The concept of cellular manufacturing systems suggests the potential to make the system more flexible, efficient, and effective [5]. Cell formation design is a staple in cellular manufacturing systems because it deals with production facilities where a number of machine and component bolts will be produced. There are three specific decisions in the design of cell formations, namely the number of manufacturing cells, the type of machine in a manufacturing cell and the type of component in each manufacturing cell [6]. The application of the Cellular manufacturing concept is realized by forming manufacturing cells in the factory. A lot of literature that discusses the techniques of designing cell manufacturing which is an important factor in cellular manufacturing. In some of the literature, the focus of the discussion is the resolution of problems such as engine formation and part families and the assessment of grouping efficiency [7][8].

The problem in this research is to design efficient and effective cellular manufacturing systems at factories that produce packaging equipment. In designing cellular manufacturing systems the three main problems to be faced are grouping of machines and components, layout planning in cells and layout planning between cells. These three main issues will be approached by applying appropriate heuristic methods. In this case, what is meant by grouping is a collection of machines and components forming finished products that have a similar process or operation. The layout in cells and between cells is a collection of machines that are arranged in such a way on the production floor that works efficiently and effectively.

This research was conducted by considering several limitations, namely the product used as a basis for planning is a superior product whose orders are repeat orders. Rearranging is done for existing machines without reducing or increasing the number of machines. Do not consider alternative process sequences. Evaluation is only on the system structure. The assumptions used in this study are that there is no change in the number of each type of machine and there is no change in the production and design processes of the products on which the planning is based. This research will be carried out in a developing medium scale industry. The results of this study are expected to provide several benefits for the practice of designing plant layouts in order to improve quality in a broad sense.

2. Literature Review
2.1 Cellular Manufacturing System

Cellular Manufacturing (CM) is a direct application of the Group Technology philosophy in the manufacturing process. Group Technology (GT) which is a philosophy that exploits the similarity of attributes between a group of objects [9]. CM represents parts as objects produced. Where as what is meant by the similarity of attributes can be in the form of similarities in the geometric shapes of parts, similarities in the production process, and so on [10][11]. A set of similar parts (part family) is formed and then processed in groups of machines (machine cells). Through the application of CM can be obtained benefits such as reduced cycle time, reduced work-in-process inventory, improved product quality, shorter leadtime, reduced tool requirements, increased productivity, better overall operating control and others [12][13].

2.2 Rank Order Clustering

By using the Rank Order Clustering method, products and machines are weighted alternately by multiplying binary quadratic values with binary values in rows and columns in the machine-product matrix [14][15]. Then the next step is to change the order of machines and products in accordance with the results of the weighting. This step is carried out until the order of machines and products has not changed [16][17]. After that step, then determine the grouping of manufacturing cells. The product machine matrix is an illustration of the machining process, this matrix explains certain products that are done with certain machines [18][19]. Products that are carried out by a particular machine are marked with a value on binary numbers, i.e. 0 and 1, if the value of 1 means the product is worked on by that machine, and if 0 means it is not worked by the machine. Weighting in columns uses the following formula:
\[ BW_j = 2^{m-j} \]
\[ DE_i = \sum_{j=1}^{m} 2^{m-j} a_{ij} \]

Where:
- BW = Biner weight
- DE = Desimal equivalen
- m, n = Column number, row number

For weighting a row uses the following formula,
\[ BW_j = 2^{n-j} \]
\[ DE_i = \sum_{j=1}^{n} 2^{n-j} a_{ij} \]

This step is carried out until the order of machines and products has not changed. After that step, then determine the grouping of manufacturing cells.

2.3 Distances Measurement Between Facilities
Rectilinier also commonly called The Manhattan, right-angle, or rectangular metric, is a measure of the distance between two items X and Y, the distance is measured by adding up the difference in the new distance with existing facilities at an absolute price [20].

\[ D (X,Y) = |x - a| + |y - b| \]

Where:
- D (X,Y) = the distance between new facilities and existing facilities
- X (x,y) = location of new facilities
- Y (a,b) = location of existing facilities

3. Methodology
In this research, the Cellular Manufacturing System is used to solve the problem at factories that produce packaging equipment. The Cellular Manufacturing System mechanism are (1) Make patriotic machinery products, (2) Grouping work cells, and (3) Counting travel times. There are 24 components that produced in the workshop section. The arrangement of machine facilities in the workshop can be seen in figure 1.

![Figure 1. Existing Layout](image-url)
From the working process of each diverse component then transferred into the form of machine-product matrix. Part 1 passes the process on a CNC milling machine (M5) CNC milling machine (M6) then it is filled in with number 1 in row 1 in columns M5 and M6 in the same way for other parts, the results of the filling can be seen in table 2.

| Part | M1 | M2 | M3 | M4 | M5 | M6 | M7 | M8 | M9 |
|------|----|----|----|----|----|----|----|----|----|
| 1    |    | 1  |    |    |    |    |    | 1  |    |
| 2    | 1  |    |    |    | 1  |    |    |    |    |
| 3    |    | 1  |    |    | 1  |    |    |    |    |
| 4    |    |    |    | 1  |    |    |    |    |    |
| 5    |    |    |    |    | 1  | 1  | 1  |    |    |
| 6    |    | 1  |    |    | 1  |    |    |    |    |
| 7    |    |    |    | 1  |    |    |    |    |    |
| 8    | 1  | 1  |    |    | 1  |    |    |    |    |
| 9    |    | 1  |    |    |    |    | 1  |    |    |
| 10   |    |    |    |    |    |    | 1  |    |    |
| 11   |    | 1  |    |    |    |    |    | 1  |    |
| 12   |    |    |    |    |    |    |    | 1  | 1  |

4. Result and Discussion

4.1 Redesign Layout

Then the work cell grouping is done using a matrix with rank order clustering method. After the layout redesign is based on the results of the previous grouping. And the layout can be seen in figure 2.

To calculate the total distance by each component, the calculation is based on the routing sheet of each component, then the calculation of total distance for one production on layout can be seen in table 3.
### Table 2. Comparison of existing and proposed distance

| i to j | x (m) | y (m) | Rectilinear (m) | Freq | Total (m) |
|--------|-------|-------|-----------------|------|-----------|
| From (i) | To (j) | Xi   | Yi   | Xj   | Yj   | |Xi-Xj|+|Yi-Yj||        |
| 1      | 3     | 21.05 | 20.25 | 30.5 | 20.97 | 10.17 | 4         | 40.68   |
| 1      | 5     | 21.05 | 20.25 | 27.84| 12.72 | 14.32 | 1         | 14.32   |
| 1      | 9     | 21.05 | 20.25 | 33.24| 10.5  | 21.94 | 1         | 21.94   |
| 2      | 7     | 22.14 | 1.92  | 30.09| 1.17  | 8.7   | 5         | 43.5    |
| 4      | 2     | 18.74 | 8.12  | 22.14| 1.92  | 9.6   | 1         | 9.6     |
| 4      | 6     | 18.74 | 8.12  | 18.74| 12.72 | 4.6   | 3         | 13.8    |
| 4      | 7     | 18.74 | 8.12  | 30.09| 1.17  | 18.3  | 2         | 36.6    |
| 5      | 6     | 27.84 | 12.72 | 18.74| 12.72 | 9.1   | 1         | 9.1     |
| 5      | 7     | 27.84 | 12.72 | 30.09| 1.17  | 13.8  | 2         | 27.6    |
| 5      | 8     | 27.84 | 12.72 | 31.42| 12.45 | 3.85  | 1         | 3.85    |
| 6      | 7     | 18.74 | 12.72 | 30.09| 1.17  | 22.9  | 2         | 45.8    |
| 6      | 8     | 18.74 | 12.72 | 31.42| 12.45 | 12.95 | 1         | 12.95   |
| 7      | 6     | 30.09 | 12.72 | 18.74| 1.17  | 22.9  | 1         | 22.9    |
| 7      | 9     | 30.09 | 12.72 | 33.24| 1.17  | 12.48 | 2         | 24.96   |
| 8      | 9     | 31.42 | 12.45 | 33.24| 10.5  | 3.77  | 2         | 7.54    |
| **Total** | | | | | | | | **335.14** |

#### 4.2 Minimize Total Distance

Based on the results of the calculation of distance that has been done in table 3, it can be compared the difference in total distance for existing condition and proposed condition.

| Layout | Total distance (m) |
|--------|--------------------|
| Existing | 411.51 |
| Proposed | 335.14 |

From table 4, it can be seen that the total distance existing layout of 411.51 m and the total distance of the proposed layout of 335.14 reduced by 76.37 m or about 18.55%.

### 5. Conclusion

Based on data analysis on research and redesign layout that has been done, the machines are grouped into 5 manufacturing cells, where cell 1 consists of a lathe and milling machine, cell 2 consists of a wire cut machine, and a tap machine, cell 3 consists of a CNC milling machine and a CNC milling machine, cell 4 consists of a milling machine CNC, and cell 5 consists of milling machines and drilling machines. From the results of the grouping reduced the total mileage that was originally 411.51 m to 335.14 m. So that the placement layout redesign proposal can be accepted because it minimizes the total distance.
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