Production floor layout design for vise manufacturing using CRAFT algorithm

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Abstract. Production floor is the core for manufacturing company. The value added activities are mostly performed in the production floor. Several factors influence a productivity of production including technology, skill of labor and production floor layout. The manufacturing company with optimal production floor layout will produce lower material flow which in turn reduce production cycle time and material handling cost. As the result, production floor layout design is necessary particularly for manufacturing with assembly product such as vise manufacturing. Several parts with different processes and materials will require high material flow between machines. If the machines are not arranged properly in production floor, it will increase material flows. This paper aims to demonstrate the design of production floor layout for vise manufacturing using CRAFT (Computerized Relative Allocation Facilities Technique) algorithm. This study produces alternative of production floor layouts by minimizing the distance between machines.

1. Introduction
Manufacturing companies focuses on producing product by changing raw materials into finished goods. Several processes might require to produce finished goods. Within these processes, more values are added to the product. These processes are performed in production floor. Hence, it is necessary to maintain the productivity in production floor in order to get high value added. However, this productivity depends on several factors such as technology, skill of labor and production floor layout. Production floor layout design refers to a plan of an optimum arrangement of machines, operating equipment, storage space, material handling equipment and all other supporting services along with the design of the best structure to contain all these facilities [1].

The manufacturing company with optimal production floor layout will produce lower material flow which in turn reduce production cycle time and material handling cost. As the result, production floor layout design is necessary particularly for manufacturing with assembly product such as vise manufacturing. Several parts with different processes and materials will require high material flow between machines. If the machines are not arranged properly in production floor, it will increase material flows. This paper aims to demonstrate the design of production floor layout for vise manufacturing.

CRAFT (Computerized Relative Allocation Facilities Technique) is one approach for designing production floor layout. CRAFT evaluates the layout by exchanging the location of departments.
Inputs for the CRAFT algorithm include initial layout, data flow or frequency of displacement, cost data per unit distance, and the number of departments that do not change or remain. For the make to order manufacturing company such as vise manufacturing, the flow of material from initial process to final process is not regular because vise consists of several parts that require different processes and materials. This certainly has an impact on the magnitude of the moment of distance transfer and may have an impact on the productivity level of the company. Based on this, the production floor layout design needs to do carefully [2]. This paper demonstrates the use of CRAFT to design production floor layouts for vise manufacturing.

2. Method
This research uses experiment as research methodology. Experiment is used because this research focuses on determining the optimal production floor layouts by evaluating the impact from arranging the machines in the layout on the distance between facilities. This research uses CRAFT algorithm to support the experiment and to find the optimal production floor layouts.

2.1. Research process
Research is started with preparing input data such as type of machines required, number of machine and from to chart. This is continued by designing initial layout and determining the centroids of the departments in the initial layout. The initial layout is developed based on the information in the from to chart.

This is followed by calculating the rectilinear distance between pairs of department centroids and stores the value in a distance matrix. Then, CRAFT updates the layout according to the best exchange and compute the new department centroids as well as the new layout cost to complete the first iteration. Next, CRAFT considers all possible two ways (pairwise) exchange and identify the best exchange which is the one that yields the largest reduction in the layout cost. The cost is determined by multiplying total movements with unit cost matrix and distance matrix. The iteration will continue.
until no further reduction in layout cost can be obtained [3][4][5]. Research process is shown in Figure 1.

2.2. Input Data
Input data used in the design of the production floor layout with the CRAFT algorithm are:

2.2.1. Machine Specification Data
The machine specification data containing the dimensions of the machine used in the production process of vise can be seen in Table 1.

| No | Symbol | Machine   | Amont | Machine Specifications (cm) | Number of Machines | Number of operators |
|----|--------|-----------|-------|-----------------------------|--------------------|--------------------|
| 1  | PM     | Entrance  | 1     | -                           | -                  | -                  |
| 2  | G      | Grinding  | 1     | 37 × 37                     | 7                  | 7                  |
| 3  | D      | Drilling  | 1     | 53 × 65                     | 2                  | 2                  |
| 4  | S      | Scrap     | 1     | 220 × 135                   | 4                  | 4                  |
| 5  | M      | Milling   | 1     | 220 × 106                   | 3                  | 3                  |
| 6  | T      | Tap and Dies | 1   | 55 × 47                     | 2                  | 4                  |
| 7  | B      | Lathe     | 2     | 172 × 84                    | 3                  | 3                  |
| 8  | A      | Assembly  | 4     | 160 × 160                   | -                  | -                  |
| 9  | PK     | Exit      | 1     | -                           | -                  | -                  |

Source: Data Collection

2.2.2. From to Chart Data
From to chart data can be seen in Table 2.

| PM | M | D | S | TD | G | B | A | PK | Total |
|----|---|---|---|----|---|---|---|----|-------|
| 0  | 0 | 0 | 0 | 20,40 | 0 | 50 | 19,20 | 0 | 89,60 |
| M  | 0 | 0 | 0 | 0 | 8,40 | 0 | 0 | 48 | 0 | 56,40 |
| D  | 0 | 21,60 | 0 | 9 | 8 | 8,40 | 0 | 0 | 0 | 47 |
| S  | 0 | 0 | 31,60 | 0 | 0 | 2 | 0 | 0 | 0 | 33,60 |
| TD | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6,80 | 0 | 6,80 |
| G  | 0 | 0 | 54 | 0 | 0 | 0 | 0 | 24 | 0 | 78 |
| B  | 0 | 0 | 14,40 | 0 | 0 | 2,80 | 0 | 0 | 0 | 17,20 |
| A  | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 20 | 20 |
| PK | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Source: Data Collection

3. Result and Discussion

3.1. Initial Production Floor Layout Design
The calculation of the station area is used by the formulas below.

Area = (Length × Scale)(Width × Scale)  
Total Area = Area × Number of Machine
Total Station Area = \frac{\text{Total Area}}{10000} \quad (3)

Selected Area = \text{the Largest Total Station Area}

Calculation of station area can be seen in table 3.

Table 3. Calculation of machines area

| Machine       | Length (cm) | Width (cm) | Area (cm\(^2\)) | Number of Machine | Total Area (cm\(^2\)) | Total Station Area (m\(^2\)) | Selected Area (m\(^2\)) |
|---------------|-------------|------------|------------------|-------------------|------------------------|-----------------------------|-------------------------|
| Drilling      | 220         | 180        | 39600            | 7                 | 277200                 | 27.72                       | 29.64                   |
| Milling       | 420         | 220        | 92400            | 2                 | 184800                 | 18.48                       | 29.64                   |
| Grinding      | 260         | 180        | 46800            | 4                 | 187200                 | 18.72                       | 29.64                   |
| Tap and Dies  | 220         | 170        | 37400            | 3                 | 112200                 | 11.22                       | 29.64                   |
| Lathe         | 350         | 300        | 105000           | 2                 | 210000                 | 21.00                       | 29.64                   |
| Scrap         | 380         | 260        | 98800            | 3                 | 296400                 | 29.64                       | 29.64                   |

Source: Data Processing

Next is the calculation of the actual production floor area. Allowance used is 80%. The calculation of the actual production floor area is shown as follows.

\[ \text{Allowance} = 80\% \]

\[ \text{Machine Area} = \sqrt{\text{Selected Area} \times (1+\text{Allowance})} \quad (4) \]

\[ = \sqrt{29.64 (1+ 0.8)} \]

\[ = \sqrt{53.35} \]

\[ = 8 \text{ m}\(^2\) \]

\[ \text{Station Area Added Allowance} = \text{Selected Area} \times (1+\text{Allowance}) \quad (5) \]

\[ = 53.35 (1 + 0.8) \]

\[ = 96.03 \text{ m}\(^2\) \]

\[ \text{Production Floor Area} = \text{Station Area} \times \text{Total Station Area} \quad (6) \]

\[ = 96.03 \times 9 \text{ Station} \]

\[ = 865 \text{ m}\(^2\) \]

\[ \text{Theoretical Production Floor Area} = \sqrt{\text{Production Floor Area}} \quad (7) \]

\[ = \sqrt{865} \]

\[ = 29.41 \text{ m}\(^2\) \]

\[ \text{Actual Production Floor Area} = \text{Rounding Up Theoretical Production Floor Area} \quad (8) \]

\[ = 30 \text{ m}\(^2\) \]

From above calculation results, the initial layout of each machine area is designed and the blocks drawn are shown in Figure 2.
3.2. Production Floor Layout Design using CRAFT Algorithm

The following is one step of the CRAFT method using WinQsb software.

1. Input From To Chart and coordinates data to the following table.

![Figure 3. From to Chart and Coordinate Data](image-url)

Here is the final layout for production floor using the CRAFT algorithm Figure 4 and 5. The design of the production floor layout obtained using the CRAFT algorithm and WinQSB software with an allowance of 80% of the station area of 8 m x 8 m and the production floor area of 30 m x 30 m is optimal because the distance between work stations obtained using the aisle distance method is 660 m.
Figure 5. Final layout for production floor of Vise Manufacturing (redraw using AUTOCAD)

4. Conclusion
This paper demonstrates the use of CRAFT algorithm in designing production floor layout for vise manufacturing. CRAFT algorithm is used to evaluate initial layout based on the distance between work centers/stations and material flow. Further work is widely open in combining CRAFT algorithm with other approach so it will be able to consider more factors in designing production floor layout. For example, to consider sustainability aspects (environmental, social and economic) in production layout design, it requires an approach that is able to use more than two factors.

References
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