Material handling selection for vise manufacturing using Hassan algorithm

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Abstract. One type of transportation in industrial companies, for moving raw materials, semi-finished goods or finished goods from their original place to destination can be called as material handling. There are several material handling equipment available for manufacturing industry such as forklift, crane, conveyor, hand truck and trolley. However, not all material handling equipment are appropriate for specific manufacturing such as vise manufacturing. The selection of appropriate and efficient material handling equipment is important for reducing material handling cost. Around 20% of production cost is allocated for material handling activities. Vise consists of several part with different processes and materials. As the result, the flow of materials between processes are high. This paper aims to select appropriate material handling for vise manufacturing. Hassan's algorithm is used as a method for selecting material handling that consider various factors such as price, time and distances. Four types of material handling namely trolley, hand truck, wheeled rack, and hand pallet, are selected in this paper.

1. Introduction
Material handling is a function of moving the right material to the right place, at the right time, in the right amount, sequentially and at the right position or condition to minimize production costs. The aim of material handling is to facilitate transportation and speed up the production process. Based on the formulation by the American Material handling Society (AMHS), the notion of material handling is stated as an art and science that includes handling, moving, packaging or packaging, storing as well as controlling or controlling (controlling) controlling) from materials or materials in all its forms [1]. There is several material handling equipment available for manufacturing such as crane, forklift, conveyor and hand truck. However, not all material handling equipment is appropriate for specific manufacture such as vise manufacturing. The use of inappropriate material handling might increase material handling cost and production time. Hence, the selection of appropriate material handling equipment is necessary [2]. This paper aims to choose the suitable material handling for vise manufacturing.

The Hassan algorithm is a way of selecting material handling by taking into account various factors such as the price of the tool, operating costs, operator costs, tool speed, tool dimensions, tool capacity, hauling distance, and transportation time. Then all types of data are calculated using Hassan algorithm calculations so that the most suitable type of material handling can be selected based on the results of the Hassan algorithm iteration.
At The Plant Layout and Material Transfer Laboratory in the Department of Industrial Engineering, Universitas Sumatera Utara, material handling selection was carried out as one of the practicum activity where the students calculated the appropriate material handling selection based on the design of the production floor [3]. The product unit used is vise, so the design of material handling selection in this study focuses on the selection of material handling for vise manufacturing where there are 9 stations on the production floor and 7 work stations, and 25 displacement in the production process. Four types of material handling are selected for the transportation of material from one station to the next in the design of this vise factory, namely trolley, hand truck, wheeled rack, and hand pallet, where each material handling has a price, cost, dimensions, speed, and capacity differ based on price and speed references obtained from data collection [4].

2. Methodology
An experiment is used as a research methodology. Experiment is good to use when the research focuses to investigate the impact of alternatives into system performance. In this research, the impacts of different material handling equipment on cost of material handling are observed. The inappropriate material handling selection have occurred for several times in manufacturing becomes a reason to conduct this experiment.

2.1. Research Process
To achieve the aim of the research, this research has been divided into three stages. Stages 1 focuses on collecting data and information required to calculate the Hassan Algorithm such as the references for the calculation of the price, cost, dimension, velocity, and capacity of each material handling. In stage 2, the focus of the research is to define the distance of each work station using aisle distance methodology, and then calculate the material handling selection using Hassan algorithm. Then, this is followed by stage 3 that is focused on choosing the selected material handling for each workstation in the production floor. Figure 1 displays the research process used in this research.

![Figure 1. Research process](image-url)
2.2. Algoritma Hassan

This section focuses to introduce the equations for each calculation model in this paper. Each calculation model has different formulation due to different factors that are considered in developing the algorithm. Table 1 shows those equations for each algorithm model [5].

| Algorithm Models | Equations | Number of Equations |
|------------------|-----------|---------------------|
| For each equipment type, calculate the number of units that would be needed if the equipment performs all the moves | $Y_i = \sum_{j} \frac{h_{ij}}{K_j}$ | (1) |
| Calculate the total cost of material handling for each equipment type as | $\lambda_t = [Y_t] + 1$ | (2) |
| Calculate the average cost for each equipment type per move as | $Z_i = \lambda_t K_i + \sum_{i,j} W_{ij}$ | (3) |
| Calculate the average cost for each equipment type per move as | $\bar{Z}_i = \frac{Z_i}{q_i}$ | (5) |

First, select the equipment with the smallest $Z_i$ and resolve ties by selecting the equipment with the smallest $Z_t$. If ties persist, resolve them by selecting in order of ascending [6]. For the selected equipment type, arrange the moves that can be performed by it in increasing order of operating cost. Assign the moves to the selected equipment starting with the move having the smallest operating cost. After each assignment, check whether the sum of $h_{ij}$ is equal to $Hi$ or within a tolerance $Ei$ of it. If the sum of $h_{ij}$ is equal to $Hi$, go to the next step; otherwise, check either of the following two cases: If the moves are the only remaining moves or cannot be assigned to another piece of equipment, leave the assignment as it is. If the sum of $h_{ij}$ is greater than $Hi$ (or a multiple of $Hi$ depending on the number of units required of the equipment so far), check the difference between the least integer multiple of $H$ (making it greater than the sum of $hi$) and the sum of $h_{ij}$. If the difference, which represents idle time, is less than or equal to $E2$ (a specified acceptable idle time), leave the assignment as it is. If the difference is larger than $E2$, remove moves from the equipment starting with the last assigned move, until the acceptable utilization level is achieved.

3. Result and discussion

This section presents results from the implementation of the hassan algorithm in the vise plant, the results of displacement totaling 25 displacements, 7 iterations and from 4 types of material handling selected and calculated, and 2 types of material handling for the production floor design at the vise factory namely trolley and wheeled shelves.

The following is the selection of material handling using the hassan algorithm:

- Salary / annual salary = IDR. 31.2 million
- Monthly salary / wage = IDR. 31,200,000 / 12 months = IDR. 2,600,000
- Salary / wage per day = IDR. 2,600,000 / 26 days = IDR. 100,000
- Hourly salary / wage = IDR. 100,000 / 7 hours = IDR. 14,286

Table 2 below shows the specification of material handling equipment used in this research.
Table 2. Data Handling Material Used

| No | Material Handling  | Price (IDR) | Dimension (mm) | Speed (m/minute) |
|----|---------------------|-------------|----------------|------------------|
| 1  | Trolley             | 312.000     | 110 cm x 63 cm | 100              |
| 2  | Hand Truck          | 305.000     | 65 cm x 45 cm  | 98               |
| 3  | Wheeled Rack        | 219.000     | 62 cm x 36 cm  | 66               |
| 4  | Hand Pallet         | 2.860.000   | 115 cm x 52 cm | 58               |

The following is the result of calculating displacement distance using the aisle distance method from another station in the vise factory based on the production process carried out.

Table 3. Distance between Stations

| Displacement | Distance (m) | Displacement distance (m) | Displacement distance (m) | Displacement distance (m) |
|--------------|--------------|---------------------------|---------------------------|---------------------------|
| G-D          | 18           | T-G                       | 18                        | G-S                       | 18                        | B-D                       | 27                        |
| D-S          | 18           | G-D                       | 18                        | S-D                       | 18                        | D-G                       | 18                        |
| S-D          | 18           | D-S                       | 18                        | D-G                       | 18                        | B-G                       | 18                        |
| D-M          | 27           | S-G                       | 18                        | S-D                       | 18                        | G-A                       | 27                        |
| M-A          | 18           | S-D                       | 18                        | D-M                       | 27                        |                           |                           |
| S-D          | 18           | D-T                       | 27                        | M-T                       | 18                        |                           |                           |
| D-T          | 27           | T-G                       | 18                        | T-G                       | 18                        |                           |                           |

The following is an example of the calculation of the material handling trolley operating costs on the G-D Displacement part.

\[
C = \frac{\text{Tool Dimensions}}{\text{Material Dimensions}} = \frac{110 \times 63}{24 \times 12.1} = 23.280 \approx 24
\]

\[
f = \frac{\text{Total Material}}{\text{Amount of Material}} = \frac{24}{4 \text{ unit/hour}} = 0.174 \approx 1
\]

\[
\text{Operational costs/minute} = \frac{\text{Cost}}{d} = \frac{1438}{66} = \text{IDR 216,455}
\]

Operational costs = \( r \times f \times \frac{\text{Operation cost}}{\text{m}} = 18 \times 1 \times 216.455 = 3896.180 \approx \text{IDR 3,896} \) (4)

Where:
- \( C \) = Carrying capacity (unit)
- Tool dimension = The size of the conveyance
- Material Dimension = The size of the unit to be moved
- \( f \) = transfer frequency
- Amount of Material = Number of units moved
- \( C \) = Carrying capacity
- Operating costs / m = Transport costs / meters (IDR / m)
- Cost = Operator Cost
- \( d \) = Speed of conveyance
- \( r \) = displacement distance
- \( f \) = displacement frequency
- \( m \) = transport cost / meter

The following is an example of calculating the operating time of a material handling hand truck on the G-D Displacement part.
The following calculation of operating costs and operating time of each move can be seen in Table 2.13.

Table 4. Calculation of Operating Costs and Operating Times

| No | Displacement | Part                  | Distanc (m) | Trolley Operating Cost (Cij) | Trolley Operation Time (Wij) | Hand Truck Operating Cost (Cij) | Hand Truck Operation Time (Wij) | Wheeled Rack Operating Cost (Cij) | Wheeled Rack Operation Time (Wij) | Hand Pallet Operating Cost (Cij) | Hand Pallet Operation Time (Wij) |
|----|--------------|-----------------------|-------------|------------------------------|------------------------------|-------------------------------|-------------------------------|---------------------------------|---------------------------------|-------------------------------|-------------------------------|
| 1  | G-D          | Base                  | 18          | 3896                         | 0.180                        | 2624                          | 0.184                        | 3896                            | 0.273                          | 4434                          | 0.310                        |
| 2  | D-S          | Base                  | 18          | 3896                         | 0.180                        | 2624                          | 0.184                        | 3896                            | 0.273                          | 4434                          | 0.310                        |
| 3  | S-D          | Base                  | 18          | 3896                         | 0.180                        | 2624                          | 0.184                        | 3896                            | 0.273                          | 4434                          | 0.310                        |
| 4  | D-M          | Base                  | 27          | 5844                         | 0.270                        | 3936                          | 0.276                        | 5844                            | 0.409                          | 6650                          | 0.466                        |
| 5  | M-A          | Base                  | 18          | 3896                         | 0.180                        | 2624                          | 0.184                        | 3896                            | 0.273                          | 4434                          | 0.310                        |
| 6  | S-D          | Left clamping body    | 18          | 3896                         | 0.180                        | 2624                          | 0.184                        | 3896                            | 0.273                          | 4434                          | 0.310                        |
| 7  | D-T          | Left clamping body    | 27          | 5844                         | 0.270                        | 3936                          | 0.276                        | 5844                            | 0.409                          | 6650                          | 0.466                        |
| 1  | B-G          | Handle                | 18          | 3896                         | 0.180                        | 2624                          | 0.184                        | 3896                            | 0.273                          | 4434                          | 0.310                        |
| 2  | G-A          | Handle                | 27          | 5844                         | 0.270                        | 3936                          | 0.276                        | 5844                            | 0.409                          | 6650                          | 0.466                        |
|    |              | Total                 |             | 109093                       | 5.040                        | 7347                          | 1.543                        | 1090                           | 7.636                          | 124140                        | 8.690                        |

An example of calculating the total cost of a trolley is as follows.

Initial Cost = Rounding Operating Time x material handling costs
= 6 x IDR 312,000
= IDR 1,872,000

Total Cost = Initial Cost + Total Operating Cost
= IDR 1,872,000 + IDR 109,093
= IDR 1,981,093

An example of Bi calculation is as follows.

The following table defines Bi Iteration 1.

Table 5. Determination of Bi Iteration 1

| Material Handling Type | Total of Displacement | Total Equipment | Rounding | Initial Cost | Total of Operating Costs | Total Cost | Bi |
|------------------------|-----------------------|----------------|----------|--------------|--------------------------|------------|----|
| Trolley                | 25                    | 5.040          | 6        | 1872000      | 109093                   | 1981093    | 79244 |
| Hand Truck             | 25                    | 5.143          | 6        | 1830000      | 73471                    | 1903471    | 76139 |
| Wheeled Rack           | 25                    | 7.636          | 8        | 1752000      | 109093                   | 1861093    | 74444 |
The following is a table of displacement and parts that experience displacement with the lowest operating costs.

Table 6. Displacement and Parts that Have Displacement with the Smallest Operating Costs

| MH Type     | Part       | Displacement | Operating Costs (Cij) | Operation Time (Wij) | Total of Operation Time (Wij) |
|-------------|------------|--------------|-----------------------|----------------------|-----------------------------|
| Wheeled Rack| Base       | G-D          | 3896                  | 0.273                | 0.273                       |
| Wheeled Rack| Base       | D-S          | 3896                  | 0.273                | 0.545                       |
| Wheeled Rack| Base       | S-D          | 3896                  | 0.273                | 0.818                       |

So for the above displacement, from stations G to D, D to S and S to D for the base parts, material handling wheel racks are used. Then all of the above calculations are carried out to obtain 7 iterations and each material handling selected. The following is a recapitulation table for each material handling selected for each material handling selected.

Table 7. The Recapitulation of Material Handling Selection

| No | Displacement | Part               | Material Handling Equipment |
|----|--------------|--------------------|-----------------------------|
| 1  | G-D          | Base               | Wheeled Rack                |
| 2  | D-S          | Base               | Wheeled Rack                |
| 3  | S-D          | Base               | Wheeled Rack                |
| 4  | D-M          | Base               | Wheeled Rack                |
| 5  | M-A          | Base               | Hand Truck                  |
| 6  | S-D          | Left clamping body | Hand Truck                  |
| 7  | D-T          | Left clamping body | Wheeled Rack                |
| 8  | T-G          | Left clamping body | Hand Truck                  |
| 9  | G-D          | Left jaw clamp     | Hand Truck                  |
| 10 | D-S          | Left jaw clamp     | Hand Truck                  |
| 11 | S-G          | Left jaw clamp     | Hand Truck                  |
| 12 | S-D          | Right clamping body| Hand Truck                  |
| 13 | D-T          | Right clamping body| Wheeled Rack                |
| 14 | T-G          | Right clamping body| Hand Truck                  |
| 15 | G-S          | Right jaw clamp    | Hand Truck                  |
| 16 | S-D          | Right jaw clamp    | Hand Truck                  |
| 17 | D-G          | Right jaw clamp    | Hand Truck                  |
| 18 | S-D          | Rotation body      | Hand Truck                  |
| 19 | D-M          | Rotation body      | Wheeled Rack                |
| 20 | M-T          | Rotation body      | Hand Truck                  |
| 21 | T-G          | Rotation body      | Hand Truck                  |
| 22 | B-D          | Crater body        | Wheeled Rack                |
| 23 | D-G          | Crater body        | Hand Truck                  |
| 24 | B-G          | Handle             | Wheeled Rack                |
| 25 | G-A          | Handle             | Wheeled Rack                |
4. Conclusion

Based on the results, some conclusions are obtained as follows

- Selection of the right material handling can reduce unnecessary waste on the production floor.
- In the calculation of material handling using the hassan data algorithm needed, among others, price, operating costs, operator costs, dimensions, speed and material handling capacity.
- There are 25 displacement distances for the entire vise production process, the distance is obtained based on the distance calculation method using the aisle distance method on the production floor.
- There are 7 iterations to get all material handling selected for each work station on the production floor.
- Of the four types of material handling determined, material handling is chosen, namely the wheel rack and handtruck based on the results of calculations and iterations using the hassan algorithm.

References

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