Modeling in order to Implementation of production balancing determination the best path to transport raw materials with the aim of improving for total expected cost

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ABSTRACT: This article Based on case study in Sanaye Felezi Iran Co. in this research, introduce a model in order to the production balance with the aim of improving for total expected cost. In the first step of research, introduce a linear programming model to determination the number of production in any production department. In the second step, by using the Hungarian allocation technique, the operator was allocated to any work stations. In the third step, introduce a Transportation programming model with the aim of improving for raw materials cost to any production departments. In the fourth step, with the use of ‘technique for order preference by similarity to ideal solution’ (TOPSIS), to determination the best transportation route, classifying material transportation routes from warehouses to assembly shop.

Key Words: linear programming, total expected cost, production, balance, classifying, Transportation.

INTRODUCTION AND PROBLEM STATEMENT

These days, daily increasing of competitive conditions in markets, customer services and essential progress in information technology and communication industries caused to satisfying the customers in appropriate quality of product, low price in comparison to other competitive and on time delivery of product, has the essential role in remaining of organizations at markets and getting the market's proportion. For this reason the concept of production balance is posed during these two decades.

Production balancing problem the issues that in recent decades, extensive studies have been done on. Production balancing problem is to ensure equal operating time according to production rate required. Among the issues that production managers are always facing, stoppages occurred in assembly lines. Among the main reasons for stoppages, not balanced production lines and not correct planning in supply of raw materials. Balances the production system reason to increasing discipline in production process and clarify the roles of staffs and timely supply of raw materials and thus increases the efficient of the production system (Javid, 2004). Balancing production model presented in this study, in composed of four main steps that reason to production balance and transportation balance with the aim of improving for total expected cost.

Literature Review

Production

Production is the act of creating output, a good or service which has value and contributes to the utility of individuals. The act may or may not include factors of production other than labor. Any effort directed toward the realization of a desired product or service is a "productive" effort and the performance of such act is production. The relation between the amount of inputs used in production and the resulting amount of output is called the production function. (Javid, 2004).
Production Balancing

Balancing problem is to ensure equal operating time according to production rate required. Production balancing problem the issues that in recent decades, extensive studies have been done on. (Javid, 2004).

Production management

The production management team (consisting of a production manager and any number of assistants) is responsible for realizing the visions of the producer and the director or choreographer within constraints of technical possibility (Javid, 2004).

Planning

Planning is the process of thinking about and organizing the activities required to achieve a desired goal. Planning involves the creation and maintenance of a plan. As such, planning is a fundamental property of intelligent behavior. This thought process is essential to the creation and refinement of a plan, or integration of it with other plans; that is, it combines forecasting of developments with the preparation of scenarios of how to react to them. (Javid, 2004).

RESEARCH METHODOLOGY

Case Study

This article Based on case study in Sanaye Felezi Iran Co. in this research, introduce a model in order to the production balance with the aim of improving for total expected cost.

Introduce a linear programming model to determination the number of production in any production department

At this stage of the research aimed at improving the total expected cost of production for each of products per hour. The decision variables are number of products that should be produced per hour. This model has five constraints shall be produced 200 products. Second to fifth constraints represent the minimum and maximum production capacity.

Figure 1. Research Practical Model
Table 1. Cost of Production any product

<table>
<thead>
<tr>
<th>Cost (Taman per hour)</th>
<th>Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>5100</td>
<td>1</td>
</tr>
<tr>
<td>4700</td>
<td>2</td>
</tr>
<tr>
<td>4900</td>
<td>3</td>
</tr>
<tr>
<td>4800</td>
<td>4</td>
</tr>
<tr>
<td>6700</td>
<td>5</td>
</tr>
<tr>
<td>4200</td>
<td>6</td>
</tr>
<tr>
<td>6100</td>
<td>7</td>
</tr>
</tbody>
</table>

Linear programming model in this step of research is:

Min \( Z = 5100X_1 + 4700X_2 + 4900X_3 + 4800X_4 + 6700X_5 + 4200X_6 + 6100X_7 \)

s.t :

\[
\begin{align*}
X_1 + X_2 + X_3 + X_4 + X_5 + X_6 + X_7 & = 6 \\
0.6 & \leq X_1 \leq 1 \\
0.6 & \leq X_2 \leq 1 \\
0.5 & \leq X_3 \leq 1 \\
0.5 & \leq X_4 \leq 1 \\
0.5 & \leq X_5 \leq 1.5 \\
0.9 & \leq X_6 \leq 1.5 \\
0.36 & \leq X_7 \leq 0.7 \\
X_i & \geq 0 ; \ i = 1,2,\ldots,7
\end{align*}
\]

Using the Hungarian allocation technique, the operator was allocated to any work stations

At this stage of the research aimed at optimum allocation of production operators to each work station based on the measured time (min) for production operations in a production cycle. (Operators are multi-purpose).

Table 2. The measured time (min) for production operations in each work station

<table>
<thead>
<tr>
<th>Work Station</th>
<th>Operators Group</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Group 1</td>
<td>107.311</td>
<td>127.9</td>
<td>66.657</td>
<td>66.39</td>
<td>171.94</td>
</tr>
<tr>
<td></td>
<td>Group 2</td>
<td>106.59</td>
<td>127.86</td>
<td>66.274</td>
<td>66.791</td>
<td>171.853</td>
</tr>
<tr>
<td></td>
<td>Group 3</td>
<td>105.88</td>
<td>129.21</td>
<td>66.429</td>
<td>66.952</td>
<td>172.1</td>
</tr>
<tr>
<td></td>
<td>Group 4</td>
<td>106.37</td>
<td>128.42</td>
<td>67.1</td>
<td>66.546</td>
<td>171.832</td>
</tr>
<tr>
<td></td>
<td>Group 5</td>
<td>106.23</td>
<td>128.73</td>
<td>66.681</td>
<td>66.588</td>
<td>171.938</td>
</tr>
</tbody>
</table>

Introduce a transportation programming model with the aim of improving for raw materials cost to any production departments

At this stage of the research aimed at improving the total expected cost of transporting raw materials from 3 warehouses to each production department. (This assembly saloon has 4 departments)

Table 3. The measured time (min) for production operations in each work station

<table>
<thead>
<tr>
<th>Work Station</th>
<th>Warehouse</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>12</td>
<td>2</td>
<td>22</td>
<td>13</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>14</td>
<td>9</td>
<td>11</td>
<td>22</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>2</td>
<td>16</td>
<td>18</td>
<td>20</td>
</tr>
</tbody>
</table>

(Costs in 100× Taman per hour)

According to the existing lift trucks (4 lift trucks exist) in factory, is the average of ability amount to carry pallets per hour from warehouses to the production departments and also is the average number of pallets needed:
With the use of ‘technique for order preference by similarity to ideal solution’ (TOPSIS), to
determination the best transportation route, classifying material transportation routes from warehouses to
assembly shop
At this stage of the research aimed at determination the best materials transportation route by any
lift trucks from warehouses to production departments. For this purpose, three indexes: distance, transportation
time and transportation cost are considered. Weights matrix is obtained by using entropy method.

Table 6. Initial table to selecting optimum transportation route by Topsis technique

<table>
<thead>
<tr>
<th>Index</th>
<th>Distance (meter)</th>
<th>Supply Quality Status</th>
<th>The Average of Transportation Time (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternative</td>
<td>Route: 1</td>
<td>63</td>
<td>Very good</td>
</tr>
<tr>
<td></td>
<td>Route: 2</td>
<td>76</td>
<td>middle</td>
</tr>
<tr>
<td></td>
<td>Route: 3</td>
<td>43</td>
<td>good</td>
</tr>
</tbody>
</table>

At this stage of the research for Qualitative values into quantitative, bipolar scale space method
has been used.

The steps of this section are
a. Determination the decision making matrix

\[
\begin{bmatrix}
53 & 9 & 4 \\
76 & 5 & 2.5 \\
43 & 7 & 3
\end{bmatrix} = A
\]

b. Determination the weighted matrix by using of entropy technique
b.1. Determination the P matrix:

\[
P = \begin{bmatrix}
0.31 & 0.43 & 0.42 \\
0.44 & 0.24 & 0.26 \\
0.25 & 0.33 & 0.31
\end{bmatrix}
\]

b.2. Determination the Ej matrix :

\[
E_j = [0.971, 0.971, 0.974]
\]

b.3. Determination the \( \bar{E} \) matrix :

\[
\bar{E} = [0.029, 0.029, 0.026]
\]

b.4. Determination the \( E_j \) matrix:

\[
W_j = \bar{E}_j \div \Sigma \bar{E}_j \\
W_j = [0.345, 0.345, 0.31]
\]

c. Determination the D matrix

\[
D = [d_{ij}]_{n \times n}, \quad d_{ij} = \frac{a_{ij}}{\sqrt{\sum_{j=1}^{n} a_{ij}^2}}
\]

\[
D = \begin{bmatrix}
0.511 & 0.722 & 0.715 \\
0.747 & 0.845 & 0.447 \\
0.423 & 0.567 & 0.536
\end{bmatrix}
\]

d. Determination the V matrix

\[
W_{n \times n} = W, V = D \times W_{n \times n}
\]

\[
\begin{bmatrix}
0.345 & 0 & 0 \\
0 & 0.345 & 0 \\
0 & 0 & 0.31
\end{bmatrix} \begin{bmatrix}
0.511 & 0.722 & 0.715 \\
0.747 & 0.845 & 0.447 \\
0.423 & 0.567 & 0.536
\end{bmatrix} = V
\]
\[\begin{bmatrix} 0.176 & 0.25 & 0.221 \\ 0.257 & 0.291 & 0.138 \\ 0.146 & 0.195 & 0.166 \end{bmatrix} = V\]

\[0.257, 0.291, 0.138\] = A
\n\[0.146, 0.291, 0.138\] = A
\n\[0.257, 0.195, 0.221\] = A
\n\[0.257, 0.195, 0.221\] = A

\[\{\max V_{ij} | j \in J\}, (\min V_{ij} | j \in J) | i = 1, 2, \ldots, m\} = A\]
\n\[\{\max V_{ij}, V_{ij}^+, \ldots, V_{ij}^n\} = \]
\n\[\{\min V_{ij}, V_{ij}^-, \ldots, V_{ij}^n\} = \]

\[\{0.146, 0.291, 0.138\} = \{\min V_{i1}, \max V_{i2}, \min V_{i3}\} = A\]
\[\{0.257, 0.195, 0.221\} = \{\max V_{i1}, \min V_{i2}, \max V_{i3}\} = A\]

f. Determination the amounts of \(d_i^+\) and \(d^-\) by using the Euclidean method

\[d_i^+ = \sqrt{\sum_{j=1}^{n} (V_{ij}^+ - V_j^+)^2} = 0.096\]
\[d_2^+ = \sqrt{\sum_{j=1}^{n} (V_{ij}^+ - V_j^+)^2} = 0.111\]
\[d_3^+ = \sqrt{\sum_{j=1}^{n} (V_{ij}^+ - V_j^+)^2} = 0.1\]
\[d_4^+ = \sqrt{\sum_{j=1}^{n} (V_{ij}^- - V_j^-)^2} = 0.0986\]
\[d_5^+ = \sqrt{\sum_{j=1}^{n} (V_{ij}^- - V_j^-)^2} = 0.1268\]
\[d_6^+ = \sqrt{\sum_{j=1}^{n} (V_{ij}^- - V_j^-)^2} = 0.1236\]

\[g.\text{ Determination the amounts of } \text{cl}_i^+:\]
\[\text{cl}_i^+ = \frac{d_i^+}{d_i^+ + d_i^-}, 1 \leq \text{cl}_i^+ \leq 1, i = 1, 2, \ldots, m\]
\[\text{cl}_1^+ = \frac{0.0986}{0.0986 + 0.0969} = 0.504\]
\[\text{cl}_2^+ = \frac{0.1286}{0.1286 + 0.111} = 0.536\]
\[\text{cl}_3^+ = \frac{0.1236}{0.1 + 0.1236} = 0.552\]

RESULTS AND DISCUSSION

**Determination the number of production in any production department**

The results of the model by using the software Win Qsb are:

<table>
<thead>
<tr>
<th>(X_i)</th>
<th>Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>X1=0.6</td>
<td>1</td>
</tr>
<tr>
<td>X2=1</td>
<td>2</td>
</tr>
<tr>
<td>X3=0.64</td>
<td>3</td>
</tr>
<tr>
<td>X4=1</td>
<td>4</td>
</tr>
<tr>
<td>X5=0.9</td>
<td>5</td>
</tr>
<tr>
<td>X6=1.5</td>
<td>6</td>
</tr>
<tr>
<td>X7=0.38</td>
<td>7</td>
</tr>
</tbody>
</table>
Table 7 shows that the optimum number of production in any production department \((X_i)\).
The results described:

a. The optimum number of production in department 1, is: 0.6
b. The optimum number of production in department 2, is: 1
c. The optimum number of production in department 3, is: 0.64
d. The optimum number of production in department 4, is: 1
e. The optimum number of production in department 5, is: 0.9
f. The optimum number of production in department 6, is: 1.5
g. The optimum number of production in department 7, is: 0.36
h. The optimum total expected cost for production is: 30222 (Taman per hour)

Determination the optimum allocation of production operators to each work station based on the measured time (min) for production operations in a production cycle

Table 8. The finally table to optimum allocation of production operators to each work station by Hungarian method

<table>
<thead>
<tr>
<th>Work Station</th>
<th>Operators Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Group 1</td>
<td>1.47</td>
</tr>
<tr>
<td>Group 2</td>
<td>0</td>
</tr>
<tr>
<td>Group 3</td>
<td>105.88</td>
</tr>
<tr>
<td>Group 4</td>
<td>0.373</td>
</tr>
<tr>
<td>Group 5</td>
<td>0.191</td>
</tr>
</tbody>
</table>

Table 8 shows that the finally table to optimum allocation of production operators to each work station by Hungarian method. Table 9 shows that the optimum allocation of production operators to each work station based on the measured time (min) for production operations in a production cycle.

Table 9. the optimum allocation of production operators to each work station

<table>
<thead>
<tr>
<th>Work Station</th>
<th>Operator Groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Group 1</td>
</tr>
<tr>
<td>2</td>
<td>Group 2</td>
</tr>
<tr>
<td>3</td>
<td>Group 3</td>
</tr>
<tr>
<td>4</td>
<td>Group 4</td>
</tr>
<tr>
<td>5</td>
<td>Group 5</td>
</tr>
</tbody>
</table>

Based on the finally result for optimum allocation of production operators to each work station by Hungarian method, the optimum total expected time for production is: 537.339 (min)

**Determination the optimum transportation amounts of raw materials**

The initial solution for this transportation problem by using Vogel method is:

Table 10. The optimum initial transportation amounts of raw materials by using Vogel method

<table>
<thead>
<tr>
<th>Work Station</th>
<th>Supply</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warehouse</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>12</td>
</tr>
<tr>
<td>2</td>
<td>14</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>

(Costs in 100x Taman per hour)

Table 10 shows that:

a. The optimum initial transportation amount from warehouse 1 to work station 2 is: 5 pallets
b. The optimum initial transportation amount from warehouse 1 to work station 4 is: 10 pallets
c. The optimum initial transportation amount from warehouse 2 to work station 2 is: 10 pallets
d. The optimum initial transportation amount from warehouse 2 to work station 3 is: 15 pallets
e. The optimum initial transportation amount from warehouse 3 to work station 1 is: 5 pallets

And based on table 10, the optimum initial total expected cost for raw materials transportation is:

\[ Z = 2 \times 5 + 13 \times 10 + 11 \times 15 + 2 \times 5 = 405 \rightarrow 405 \times 100 = 40500 \text{ (Taman per hour)} \]
Table 11. The optimum finally transportation amounts of raw materials by using Vogel method

<table>
<thead>
<tr>
<th>Work Station</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warehouse</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(Costs in 100× Taman per hour)

Table 11 shows that:

- a. The optimum finally transportation amount from warehouse 1 to work station 2 is: 5 pallets
- b. The optimum finally transportation amount from warehouse 1 to work station 4 is: 10 pallets
- c. The optimum finally transportation amount from warehouse 2 to work station 2 is: 10 pallets
- d. The optimum finally transportation amount from warehouse 2 to work station 3 is: 15 pallets
- e. The optimum finally transportation amount from warehouse 3 to work station 1 is: 5 pallets

Based on table 11, the optimum finally total expected cost for raw materials transportation is:

\[ Z = 5 \times 2 + 10 \times 9 + 10 \times 13 + 15 \times 11 + 5 \times 2 = 405 \times 100 = 40500 \text{(Taman per hour)} \]

THE RESULTS DESCRIBED

- a. The optimum number of production in department 1, is: 0.6
- b. The optimum number of production in department 2, is: 1
- c. The optimum number of production in department 3, is: 0.64
- d. The optimum number of production in department 4, is: 1
- e. The optimum number of production in department 5, is: 0.9
- f. The optimum number of production in department 6, is: 1.5
- g. The optimum number of production in department 7, is: 0.36
- h. The optimum total expected cost for production is: 30222 (Taman per hour)

Determination the best transportation route, classifying material transportation routes from warehouses to assembly shop by using Topsis technique

Table 12. The finally table of classifying the transportation routes

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Classifying</th>
</tr>
</thead>
<tbody>
<tr>
<td>Route: 1</td>
<td>third</td>
</tr>
<tr>
<td>Route: 2</td>
<td>second</td>
</tr>
<tr>
<td>Route: 3</td>
<td>first</td>
</tr>
</tbody>
</table>

Based on table 12

- a. The optimum raw materials transportation route is: 3
- b. Transportation distance is: 43 meter
- c. Supply Quality Status is: good
- d. The average of transportation time is: 3 minutes

CONCLUSION

The aim of this study is determination the optimum production plan, the optimum transportation rate, the optimum transportation time, the optimum transportation distance, the optimum allocation of operational operators to work stations and the optimum total expected cost for production and transportation, in determination of the optimum transportation route, considered in terms of: supply cost, supply time, supply quality status. Determination the optimum production plan, production rate, the optimum allocation of operational operators, the optimum transportation route in terms of any indexes motive to enhanced power management decisions when faced with decision making in different situations due to market fluctuations and customers orders. This model can help to selecting of optimum supplier in a supply network or supply chain. Propose that this model use in real conditions with real data and limitations.

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