Improving Layout and Workload of Manufacturing System in Small and Medium Enterprise (SME) using Delmia Quest

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ABSTRACT

A facility layout can be defined as an arrangement of the equipment area in the industry or organization of the factory. The main objective of this project was to improve the existing layout in SMEs using DELMIA QUEST simulation. In this project, new layouts are proposed to reduce the waiting time in a production line and increase the productivity. This study focused on packaging production line of a coffee manufacturing company located in Tasek Gelugor Pulau Pinang. The problems identified in this production line are limited working space, some processes overlap and are stuck due to high demands of the products. This results in high lead time. The existing layout was studied and simulated to improve certain parameters such as labour, machines, and shape of the layout. The workstations were repositioned in the proposed layout before undergoing simulation process using DELMIA QUEST software. From the simulation results, the significant improvement was determined and the best layout was chosen in terms of machines utilization and total output. Based on this, a new layout is proposed to increase the productivity capacity and to meet customers’ demands. Simulation data of the proposed layout showed its productivity had increased to approximately 41.5%.

Keywords: manufacturing; facility layout; Small and Medium Enterprise (SMEs); productivity improvement; DELMIA QUEST software.

1. INTRODUCTION

The SMEs Food industry grows and changes continuously, re-evaluates product specification changes accordingly with customer needs, technology that grows quickly every day, and workers going in and out of a company. Food industry is facing a quite more competitive environment and is under pressure because of the increasing market demands and changing customer choices. Most enterprises contribute to the improvement of the Malaysian economy. The efficient use of resources and effectiveness of operations are very important for companies to compete in the market where layout improvement should be adopted as a competitive strategy by SMEs.

The performance of SMEs is influenced by the layout design. The fundamental concept behind this layout design is to reduce cost and to ensure workforces to complete their work faster and at the same time meet the needs and demands of the customers. The lack of performance can be discovered when the production line is slow and the inventory is high. Improper layout may cause problems such as products will be delayed when the products
need to be delivered to another machine or department [1]. To create the most efficient plant layout, elimination of waste is needed to be properly planned in order to improve productivity [2]. The wasted elements include overproduction, motion, defect, over-processing, inventory (WIP), and waiting time [3, 4].

This would make the effort of improving the existing layout becomes more significant because of the potential profit that will bring to the SMEs and effort to face a global challenge. In general terms, facility layout may be defined as the location of all machines, utilities, employee workstations, material storage areas, restrooms, lunchrooms and flow production [3]. The facility layout plays an important role in improving SMEs performance [5]. The facility layout affects the overall productivity of the facilities [6]. It has been noted that most of the problems faced by the majority of SMEs are layouts and poor management plans. These will affect some things such as transport schedules, and cause high rejection rates, high lead times, large inventories and affect satisfaction of customers [1,7]. Previous research mentioned that the best layout of facilities should cover these objectives such as eliminating and reducing bottlenecks, reducing walking distance of workers, minimizing inventory, improving delivery of goods and eliminating unnecessary work [8, 9, 10].

Since the 1960s, simulation has been used in the industry mostly in relation to the arrangements, process, planning and production scheduling [11]. Simulation technique is widely applied in SMEs industry [3]. The implementation of the simulation has reduced production cost by eliminating unnecessary processes. Based on the previous studies, the tool often used in solving the waste problem in production line is DELMIA Quest Software. This software is used to create a simulation for making an estimation of the system’s performance existing layout. This software is mainly adopted by large companies and has been proven to be a powerful tool in analysing the best layout for an SME in industry [5, 6]. In addition, re-layout of the physical layout will involve high costs but applying simulation requires minimal costs and saves time in modelling the layout first and testing performance [8,10].

Therefore this paper intends to address the main problem faced by the studied company which is its inability to fulfil customer demands for 2 in 1 Robusta coffee product. The important concern related to the problem at packaging line is that some of the machines are not fully utilized. With regard to the situation, to ensure that the layout is good, less problematic and systematic, selection of the right process layout is crucial. New layouts were simulated using DELMIA QUEST Software and compared with the existing layout in the company in terms of output, machine utilization and manpower utilization.

2. CASE STUDY DESCRIPTION

2.1 General Floor Layout

The Quest model analysed was based on a manufacturing facility of a coffee-making medium-sized company located at Tasek Gelugor, Pulau Pinang. This manufacturing facility has 22 machines and seven workstations, and produces six different products in their manufacturing plant. Figure 1 shows the 2D layout and Figure 2 shows the top view of the model layout for this project. In the existing layout, there are eight labours for the process. From the observation, labour capability has not been utilized effectively. This happens because the process is designed without considering the distance travel of workers from one process to another.
3. METHODOLOGY

The company was visited in order to evaluate the existing production line condition before making any improvement and also to collect data. All the data gathered then was used for the DELMIA QUEST Simulation. The actual data such as the process flow, cycle time, total production output per day and number of workers were needed. The simulation was conducted for actual improvement without disrupting the company’s production line. With this, the company would know the initial expected outcome of the improvement before and after implementation.

3.1 Alternatives Layout Design
There were two stages before the final design was simulated using DELMIA QUEST. In the first stage, the existing layout was modelled using DELMIA QUEST Software with three alternative layout designs. All the designs of layouts were constructed by performing simulation. The simulation was modelled for eight working hours. In the second stage, the results generated were compared to the existing layout and the best alternative was chosen. Figure 3, Figure 4 and Figure 5 show the alternative layouts. Figure 3 shows the cooking and breaking departments were placed close to each other. The grinding machines were placed in a straight line to reduce material handling time after mixing process as well as to enable the placing of the sifter machines closer to it. The cooking and breaking departments were rotated to reduce travelling time for an average of one minute for worker to load the materials to the cooking machines and this is shown in Figure 4.

Figure 3: Alternative 1
Figure 4: Alternative 2

Figure 5 shows the roaster machine was positioned near to the raw materials. The cooking and breaking departments were placed close to each other. The mixer, grinder and sifter machines were placed in the same department to reduce material handling time to 5 minutes before proceeding to WIP product process and packaging department area.

Figure 5: Alternative 3
4. RESULTS AND DISCUSSIONS

4.1 New Layout

Three alternative layouts were built up and simulated for this project by using DELMIA QUEST software. The first simulation was done for the existing layout and the second simulation was for the alternative layouts. Figure 6 shows the existing layout (3D Model) for the packaging line with the connection between elements from the sachet packaging to the output. As seen in this figure, machines are placed in L-shape line before changing to the straight-shape line.

Figure 6: Existing Layout (3D Model)

Figure 7 shows the alternative 3 layout (3D Model) for the packaging line with the connection between elements from the sachet packaging to the output (finished goods). The make-sachet machines were placed in a straight line in order to reduce material handling time to five minutes after the mixing process. There were three make-sachet machines rearranged to reduce travelling time for an operator to load the WIP product to the next process which was small packaging. The big packaging and boxing machines remained at the same position. All the elements were designed based on the cycle process time and the real process sequence.
4.2 Simulation Report

The case study results were evaluated based on the performance analysis of the production line through DELMIA QUEST simulation. A comparison between the existing and alternative production layouts was carried out to investigate the manufacturing performance. Table 1 lists down the elements involved for the comparison between the alternative layouts. It clearly shows that the Alternative 3 layout produced the best results. The Alternative 3 layout productivity was 4.09 which was greater than the productivity existing layout of 2.89. The productivity improvement of the layout was increased up to 41.5%.

Table 1: Comparison between Alternative Layouts

<table>
<thead>
<tr>
<th>Items</th>
<th>Alternative 1</th>
<th>Alternative 2</th>
<th>Alternative 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Finished parts (boxes/day)</td>
<td>155</td>
<td>155</td>
<td>229</td>
</tr>
<tr>
<td>2. Manpower</td>
<td>13</td>
<td>13</td>
<td>7</td>
</tr>
<tr>
<td>3. Work-in-Progress (boxes/day)</td>
<td>250</td>
<td>250</td>
<td>250</td>
</tr>
<tr>
<td>4. Average Manpower Utilization (%)</td>
<td>11.67</td>
<td>21.28</td>
<td>53.40</td>
</tr>
<tr>
<td>5. Average Machine Utilization (%)</td>
<td>60.2</td>
<td>60.1</td>
<td>66.4</td>
</tr>
<tr>
<td>6. Average Process Time (minute)</td>
<td>11.4</td>
<td>11.43</td>
<td>6.4</td>
</tr>
<tr>
<td>7. Average Cycle Time (minutes)</td>
<td>9.7</td>
<td>9.6</td>
<td>6.3</td>
</tr>
<tr>
<td>8. Average Production Rate</td>
<td>0.06</td>
<td>0.06</td>
<td>1.35</td>
</tr>
<tr>
<td>9. Productivity (boxes/man-hour)</td>
<td>1.49</td>
<td>1.49</td>
<td>4.09</td>
</tr>
</tbody>
</table>
Table 2: Comparison between Existing layout and Alternative 3 layout

<table>
<thead>
<tr>
<th>Item</th>
<th>Existing Layout</th>
<th>Alternative 3 Layout</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Finished parts (boxes/day)</td>
<td>185</td>
<td>229</td>
<td>44 (23.8%) increased</td>
</tr>
<tr>
<td>2. Manpower (numbers)</td>
<td>8</td>
<td>7</td>
<td>1 (12.5%)</td>
</tr>
<tr>
<td>3. Work-in-Progress (boxes/day)</td>
<td>250</td>
<td>250</td>
<td>-</td>
</tr>
<tr>
<td>4. Average Manpower Utilization (%)</td>
<td>48.44</td>
<td>53.4</td>
<td>4.96 (10.2%)</td>
</tr>
<tr>
<td>5. Average Machine Utilization (%)</td>
<td>64.4</td>
<td>66.4</td>
<td>2 (3.1%)</td>
</tr>
<tr>
<td>6. Average Process Time (minute)</td>
<td>6.4</td>
<td>6.4</td>
<td>-</td>
</tr>
<tr>
<td>7. Average Cycle Time (minutes)</td>
<td>6.4</td>
<td>6.3</td>
<td>0.1 (1.6%)</td>
</tr>
<tr>
<td>8. Average Production Rate (minutes)</td>
<td>1.38</td>
<td>1.35</td>
<td>0.03 (2.17%)</td>
</tr>
<tr>
<td>9. Productivity (boxes/man-hour)</td>
<td>2.89</td>
<td>4.09</td>
<td>1.2 (41.5%) increased</td>
</tr>
</tbody>
</table>

Table 1 and Table 2 show the simulation result comparison between the existing layout and alternative layout for machine utilization. Machine utilization was slightly better for the alternative layout. Besides that, processing time slightly decreased in the proposed layout as it was a re-layout from L-shape to Straight-shape. However, the cycle time remained constant. Despite this, the production rate was still slightly better for the alternative layout. Based on the DELMIA Quest Simulation results, the differences between the existing layout and the best alternative layout were tabulated in Table 2.

The results showed an improvement in the total production output and average machine utilization. Table 2 shows the details of the comparison parameters between the existing and alternative plant layouts. Based on the results obtained as shown in Table 2, if the company implemented the alternative layout as suggested, the production output can be increased by 23.8%. The alternative layout showed an increase in productivity produced than the existing layout with manpower reduction from eight to seven. The total production output can be increased up to 44 boxes per day. This improvement is the result of the elimination of the bottleneck at the small pack process by arranging the machines in a straight-line shape. Then, the machine utilization can be increased up to 2.0% through reducing the distance. As for the number of workers, it can be reduced by 12.5% through one worker doing multiple jobs in the line. Lastly, for the productivity, it can be increased up to 41.5%.
5. CONCLUSIONS AND RECOMMENDATIONS

DELMIA QUEST simulation has proven its capability to simulate the manufacturing process. The improvement can be evaluated by comparing the effectiveness, flexibility and productivity between the actual results and simulation results. For this project, the results from DELMIA QUEST Simulation showed that the company’s production can be improved by eliminating the non-value activities added in the production line. It is expected that the implementation of the proposed model will help the overall improvement of the company’s production performance. To implement the alternative layout design, total re-layout of line layout is not required. However, the re-layout process should give a considerable attention to the position of workstation as shown in alternative layout design. The new layout positions in the packaging line will help to reduce material handling and movement of workers. Furthermore, no extra space is required to implement the alternative layout design.

In order to compete in the food industry, several initiatives should be taken such as re-arrangement of some of the process departments. The objectives of the line improvement are to reduce waste by increasing productivity and to cause a reduction in work-in-progress. Any improvement for line layout should be considered in order for it to comply with the requirements by some government bodies to acquire HALAL and MESTI certificates. In SMEs industry, simulation software can be a tool to use when choosing the best production layout. Therefore, SMEs companies are recommended to use simulation in order to re-layout their production line.

REFERENCES

