Layout optimization of machining process of the side frame of cotton ginning M/C using FLP

Ketan Agrawal¹, Ashish Paharia²

¹Student, Takshila Institute of Engineering and Technology, Jabalpur, Madhya Pradesh
²Assistant Professor, Takshila Institute of Engineering and Technology, Jabalpur, Madhya Pradesh

ABSTRACT

The objective of this research is to study the existing layout of a machining process unit and to design a lean plant layout using SLP (Systematic Layout Planning) to increase its productivity and reduce the material handling cost. Factory layout involves the arrangement and selection of machines, material handling devices, material handling path, resulting in the reduction of cost and time involved in manufacturing a product. The facilities layout problem, which is an integral part of facilities design, aims to spatially locate the production units within a facility subject to some design criteria and area limitations, with one or multiple objectives.

In this, a hybrid model that combines a facility allocation technique and a software analysis of the layout is done. Select the best block layout of the machining section with the help of Relative Allocation of Facilities Technique. After selecting the best block layout detailed layout is constructed and this detailed layout is analyzed using ARENA. The installed utilization of the layout is checked. The utilization of the layout is increased by changing the position of the equipment or by introducing a new machine into the layout. With the advent of software which allowed the user to build models and move them around the screen and analysis can be done. Re-layout can also be done until a satisfactory result is obtained.

Keywords: Activity relationship chart, Systematic layout planning, Simulation, Arena.

1. INTRODUCTION

The process plant layout problem mainly considers the spatial arrangement of equipment items in plants and the required connections among them. Plant layout has been considered as one of the most important issues in the design stage of process plants due to the increasing competition in process industries; restrict environment regulations and product specifications.

Plant layout is the arrangement of physical facilities such as machinery, equipment, furniture etc. within the factory building in such a manner so as to have quickest flow of material at the lowest cost and with the least amount of handling in processing the product from the receipt of material to the assembly section of the finished product.

The manufacturing industry is always under the pressure from their shareholders to improve productivity. Industries are not only being compared to their competitors but also within their own group of companies. The facility layout of manufacturing consists of configuring the plant site with lines, buildings, major facilities, work areas, aisles and other pertinent features such as departmental boundaries.

The systematic layout planning (SLP) is a tool used to arrange a workplace in a plant by locating areas with high frequency and logical relationships close to each other. The process permits the quickest material flow in processing the product at the lowest cost and least amount of handling.

![Fig. 1 Procedure of SLP](image-url)
Many researchers have been done in finding the optimum facility design either using heuristic methods or simulation technique. Facility layout can be tackled by graph theory approaches considering units and connections as nodes and arcs and maximizing the adjacencies among nodes (Kim and Kim, 1995; Caccetta and Kusumah, 2001). Chee (2009) was developed two layout designs using SLP and both designs has two simulation models evaluated by ARENA software. The results are compared in terms of traveling distance, traveling time, traveling cost, output, average resource utilization, average waiting time and total time spent in the system. A facility is an entity that facilitates the performance of any job. It may be a machine tool, a work center, a manufacturing cell, a machine shop, a department, a warehouse, etc. (Heragu, 1997). Facilities layout is important in a manufacturing system as it contributes significantly to productivity in terms of cost and time (Raman, D., 2007). The most important example of this approach can be systematic layout planning-SLP procedure, suggested by Muther (Muther, 1988). In recent years, with the improvement of the computer performance and the development of the digital analysis methods, computer-aided system layout planning (CASLP) method appears based on applying computer and its related technologies to SLP method (Lan et al., 2005). The changes of production planning, technological process, production organizational mode and material handling will all affect the facility distribution scheme of a production line (JIA et al., 2006). Sahin et. al. (2009) investigated the two approaches for the facility layout problem. The first one is the quantitative approach aiming at minimizing the total material handling cost between departments based on a distance function. Ermin et. al. (2007) developed the overall factory layout in spite of limitation in size, position and unit relationship. He also modified SLP to use this procedure for different shapes and hexagons.

Several facility planning techniques could be used to develop a new layout or improve the current layout such as Systematic Layout Planning (SLP), Pairwise Exchange Method (PEM), Graph-Based Theory (GBT), Dimensionless Block Diagram (DBD), Total Closeness Rating (TCR), etc. In this study, three facility planning methods have been used to design the sustainable layouts which are SLP, GBT, and PEM.

2. BACKGROUND OF ORGANISATION

XYZ Company is a machining process factory that has a part which name is side frame of cotton ginning machine. The part machined by four machines and inspected on two places between machining process. XYZ Company has facing problems in machining process of the part is more transportation of part between machines. Due to that reason productivity of industry is less.

At present, XYZ Company machined 12 parts per shift and transportation time 12.5 minutes. Due to more transportation distance, the cost of material handling is also more it is 8,73,000 Rs. Flow process chart of machining process of the side frame of cotton ginning machine is given below in fig. 2.

Present layout of machining process of the side frame of cotton ginning machine is given below in fig. 3. The problems in present layout are given below-

- Transportation distance,
- Material handling cost,
- Total Space cover for complete machining,
- Loading and unloading time.

3. METHODOLOGY

A. Data collection

In that study, examine the current plant layout. There are many elements in the layout and these elements are related to one other. In order to analyze the present layout, the study looks at the machining process and utilization of space, machinery and transfer distance between machines.
Flow process chart of the methodology is given below in fig. 4.

**Fig.4 Flow process chart of the methodology**

**B. Activity Relationship chart**

Relationship diagramming is a central technique in Systematic Layout Planning (SLP). The activity relationship diagram converts vowel-letter ratings on the relationship chart to a graphic visualization of desired closeness among activity-areas. An activity relationship chart (ARC) is one that displays the closeness rating among all pairs of activities or departments. In an ARC there are six closeness ratings which may be assigned to each pair of departments.

![Activity Relationship Chart](chart)

**Ranking in terms of degree of Nearness/Closeness necessary:**

- **A** – Absolutely Essential
- **E** – Especially Necessary
- **I** – Important
- **O** – Ordinary
- **U** – Unimportant
- **X** – Not Desirable

**C. Transfer Distance**

The distance between the machines and inspection sections are given in Table 1:

<table>
<thead>
<tr>
<th>No</th>
<th>To Description</th>
<th>From Description</th>
<th>Distance (meter)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The raw material storage center</td>
<td>Drilling machine (CNC-NX2215)</td>
<td>6</td>
</tr>
<tr>
<td>2</td>
<td>Drilling Machine (CNC-NX2215)</td>
<td>Inspection(1) area</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>Inspection Area(1)</td>
<td>Planomiller machine</td>
<td>12</td>
</tr>
<tr>
<td>4</td>
<td>Planomiller machine</td>
<td>RDM(1)</td>
<td>10</td>
</tr>
<tr>
<td>5</td>
<td>RDM(1)</td>
<td>Inspection (2) area</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>Inspection(2) area</td>
<td>RDM (2)</td>
<td>3</td>
</tr>
</tbody>
</table>

**4. ANALYSIS AND FINDINGS**

Analyses were carried out based on the methodology adopted. In this section discusses the current machining process, evaluates the current facilities layout according to the systematic layout planning (SLP) procedure and describes the elements considered. In this section on current machining process, some calculation based on the capacity of machining and the cost of material handling will be discussed. The chapter then highlights the difference between the current facilities layout and proposed new layout based on a simulation model using ARENA software.

There are six activities in the current production process, which apply to all of its products. Figure 1 and Table 1 shows the current process and the transfer distance. Figure 5 shows the simulation model for the current process of XYZ Company while Figure 7 shows the model of the proposed current process for XYX Company using ARENA software. Each model consists of all machining process and inspections. Figure Shows the best model of machining process of the side frame of cotton ginning machine obtained after we run the simulation that proposes to XYZ Company. The distance of machines are decreasing by the changing the location of machines.

![Simulation Model for Current Process](model)

**A. Calculation of Material Handling cost of current layout**

a. Material Handling Cost for handling the part by Manual Pallet Stacker-
• The rate of manual handling the part in industry = 13 Rs/min
• In Complete production cycle of one part, Handle the part from one station to another station = 4 times
• Total number of parts manufactured in one shift (8hr.=480 min.) = 12 parts
• Total material handling time (/transfer time) of one part = 12.5 min
• Total material handling time in one shift = 12.5 × 12 = 150
• Total material handling cost by manual pallet stacker in one shift = 1950 Rs

b. Material Handling Cost for loading and unloading the part in the machine by Overhead Monorail Crane
- Loading and unloading each part by crane in 4 machines.
- Total number of loading and unloading by crane in one shift = 4×12 = 48 times
- Total time for Loading and unloading one part in 4 machines by crane = 42 min.(avg.)
- Total time when crane is used for loading and unloading the part in one shift = 504 min
- The rate of material handling by crane=25 Rs/min
- Total material handling cost by crane in one shift=12600 Rs per shift

c. Total material handling cost per month for two shifts =14550×2×30 = 873,300 Rs

B. Proposed Layout
After changing the location of machines found a new layout that is given below in figure 6. In that changed the location of machines, loading and unloading equipment (in place of crane hook using magnetic crane). Also, Use the magnetic plate for holding the part into the Radial Drill Machine.

C. Calculation of Material Handling cost of new proposed layout
a. Material Handling Cost for handling the part by Manual Pallet Stacker-
- Total number of parts manufactured in one shift (8hr.=480 min.) = 14 parts
- Total material handling time (/transfer time) of one part = 6.0 min
- Total material handling time in one shift = 6.0 × 14= 84 min
- Total material handling cost by manual pallet stacker in one shift = 1092 Rs

b. Material Handling Cost for loading and unloading the part in the machine by Overhead Monorail Crane
- Total time for Loading and unloading one part in 4 machines by crane = 26 min(avg.)
- Total time when crane is used for loading and unloading the part in one shift = 26×14 = 364 min
- The rate of loading and unloading by magnetic lifting crane =30 Rs/min
- Total material handling cost by crane in one shift = 364×30 = 10920Rs
Total material handling cost per month for two shifts = 12,012×2×3 = 720,720 Rs

D. Comparison table of Current Layout and Proposed Layout:

In that table all the data of current and proposed layout are compared:

Table 2 Comparison of Current and Proposed Layout

<table>
<thead>
<tr>
<th>S. No</th>
<th>PARAMETERS</th>
<th>PRESENT LAYOUT</th>
<th>FINAL PROPOSE LAYOUT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Parameters</td>
<td>Average</td>
<td>Min.</td>
</tr>
<tr>
<td>1</td>
<td>Total no. of parts</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Manufactured</td>
<td>Avg. 211.4</td>
<td>Min. 208.8</td>
</tr>
<tr>
<td>2</td>
<td>Waiting Time in min</td>
<td>20.1437</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>Transfer time in min</td>
<td>12.5</td>
<td>12.5</td>
</tr>
<tr>
<td>4</td>
<td>Total time in min</td>
<td>244.05</td>
<td>222.12</td>
</tr>
</tbody>
</table>

OTHER

<table>
<thead>
<tr>
<th>S. No</th>
<th>PARAMETERS</th>
<th>PRESENT LAYOUT</th>
<th>FINAL PROPOSE LAYOUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Total Number In Part</td>
<td>26</td>
<td>26</td>
</tr>
<tr>
<td>7</td>
<td>Total Number Out Part</td>
<td>17</td>
<td>19</td>
</tr>
<tr>
<td>8</td>
<td>WIP Part</td>
<td>10.0969</td>
<td>0</td>
</tr>
</tbody>
</table>

WAITING

<table>
<thead>
<tr>
<th>S. No</th>
<th>PARAMETERS</th>
<th>PRESENT LAYOUT</th>
<th>FINAL PROPOSE LAYOUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>Waiting Time till 3 parts</td>
<td>20.2674</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>arrived in min</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Waiting part till 3 parts</td>
<td>0.9274</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>arrived, queue</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Total Loading and</td>
<td>42.35</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td>Unloading Time in min</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

COST

<table>
<thead>
<tr>
<th>S. No</th>
<th>PARAMETERS</th>
<th>PRESENT LAYOUT</th>
<th>FINAL PROPOSE LAYOUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>Total Material Handling Cost Per month for 2 shift</td>
<td>8,73,800</td>
<td>7,20,720</td>
</tr>
<tr>
<td>13</td>
<td>Space Reduce in square meter</td>
<td>62</td>
<td></td>
</tr>
</tbody>
</table>

After comparing the data of present and final propose layout clear that improve layout is best as compare to present layout. For easy understanding of comparison, draw bar figure below:

Fig. 8 Comparison of Avg. Total Time before and after

Fig. 9 Comparison of Material Handling Cost before and after

Fig. 10 Comparison of Transfer Time before and after

5. CONCLUSION

The goal of this study is to develop a new machining layout for machining process of the side frame of cotton ginning machine of XYZ Company, in view of the need to increase the machining capacity using facility planning and design techniques. The first step is to generate several layouts to raise the probability of finding the sustainable layout with higher efficiency, and the second step is to select the best layout and improve it.

SLP and GBT are two types of construction techniques for facility planning. In this study using SLP for improvement of the layout. Three alternative layouts were generated in this study using SLP. The layout with the lowest transportation distance and material handling cost was selected as a sustainable layout among other alternatives. To avoid lengthy calculation and to increase the precision of the algorithm ARENA software was opted. The input of this program was the order of departments in a spiral way. The output was the improved layout which is the improved order of departments in a spiral way.

After implementing the SLP technique, machining of the side frame of cotton ginning machine increases from 12 to 14 parts and transportation time decreases 12.5 min to 6 min. And material handling cost is also reducing 153,080 rupees. Based on this study, it is found that even the best-selected layout
could be improved. Therefore, the result indicates that it is necessary to conduct facility and layout planning before any factory set up to ensure sustainable process and reduce losses.

The atmosphere of the company also affects the productivity. After implementing the SLP technique, the atmosphere of the industry is also good, due to reduce accidents because of reducing handling of the part between machines and sections.

6. REFERENCES


