Improvement in Manufacturing System by Rearrangement in Layout Design – A Case Study

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Abstract: Market demands are rising deliberately. Continuous modification in design with improved features has become a necessity to survive in the present competitive market. This throughout adaptation of new features and techniques is a great challenge to the manufacturing system. It is tough call for any firm to organise its layout against the change in design and type of product. The change in layout is tedious and costly for small scale industries with job shop system. Thus, improvement in facility layout should be such that it is easily flexible to the changed scenario. Also it should enhance productivity by reducing the distance flow, lead time and wastage. A case study was carried out at a job shop production industry - Bluebird Lights Pvt. Ltd. Delhi, India. After the analysis of the present layout, a revised layout plan was optimised for its variety of products being manufactured.

Keywords: Manufacturing System, Plant Layout, Product Layout, Cellular Layout, Systematic Layout Planning, Group Technology

1. Introduction

The basic meaning of manufacturing process is the series of steps used to convert raw materials into a final product to fulfill a desired function. And the system comprising of arrangement of such operations and processes to make a prerequisite product is known as manufacturing system. The major sections of any manufacturing system are design, raw materials, technology, man power, tools, techniques, testing, inspection, quality control, storage and transportation.

All the sections play an equal role to produce a good finished product. The success of the firm depends on the success of its product. It is known that any change in design, requires change in tools and techniques along with the change in operations. So, the layout of the manufacturing system should be adjustable to such changes like changes in design, operations, production volume, product type, tools and techniques etc.

If the layout of the firm is efficient, it can handle the fore coming changes in the production system. Moreover a good layout of any manufacturing system often leads to better space utilization, reduction in cycle time, trimming down the inventory costs, proper on- time delivery, efficient management, clear roles and responsibilities to the employees and workers.
2. Manufacturing System and Layout Concepts
The decision on the type of layout system to be adopted is directly dependent on the type of manufacturing system. A particular type of layout is designed for a particular type of production system. However, according to the available facility and the production volume; the layout can be modified accordingly. The various types of manufacturing systems are discussed below.

2.1. Types of manufacturing systems
The various types of manufacturing systems in the industry are described below.

2.1.1. Job Shop. In the job shop, small batches of a variety of custom products are made. Lot size is small to achieve maximum flexibility. High skilled workers are required. The type of layout adopted for the job shop is process (functional) layout. Various examples of job shop system are small bakery shops, car customization shops, printing press, electronics parts manufacturing shops etc.

2.1.2. Flow Shop (batch production). In the flow shop, a particular product is manufactured at a high production rate. Here, the work can be handled by low skilled worker. The type of layout chosen is product type layout. The common examples of the products of this shop are cold drinks, brewages, televisions etc.

2.1.3. Project Shop. This is another type of layout in which the product position is fixed and the required materials, machines and human power are brought there. The product size is generally large. The type of layout adopted in this shop is fixed position layout. Some examples for this shop are locomotive manufacturing, ship building, rocket manufacturing, aircraft manufacturing etc.

2.1.4. Continuous process. In this type of shop, facilities are arranged according to the sequence of operations right from beginning to the final product. Large material handling devices like conveyors, pipelines etc. are used. Unit cost is less and production volume is quite large. Various examples include coal mining processes, coal handling plants, oil refineries, food processing industries etc.

2.2. Types of Layouts
The concept of plant layout in manufacturing system is that it is a plan for effective utilisation of facilities for the manufacture of products; having a most efficient and economical arrangement of machines, materials, personnel, storage space, manpower all other services within the available floor space.

2.2.1. Process Layout. In process layout, all machines doing similar job applications are assigned at one location and the ones performing the other are assigned at the other. Thus the grouping of machines is done based on the functions they perform. Process layout is suitable for shops with variety of products and low production volumes. The various benefits of process layout are flexibility, better utilization of machines, proper arrangement of facilities, varieties in products. However, the production rate is low due to long flow paths and backtracking can be seen which reduces the overall efficiency.

2.2.2. Product Layout. In product layout, machines are arranged according to the sequence of the operations. This is efficient when the production volume is large. This reduces cost per unit item. Any two products produced in product layout may have different sequence of operations. Various advantages of this type of layout involves smooth flow of product, less in-process inventory, efficient routing, less space occupation by accessories, decrease in manufacturing cycle time etc.

2.2.3. Combination Layout. Combination layout is the combination of process and product layout. Thus it is compatible to both large and small scale productions. Here, the machines are aligned
according to the process layout and the process grouping is arranged in accordance with the type and size of products.

2.2.4. Fixed Position Layout. This layout is unique according to its name. In this, the materials and components to be processed are fixed in a location and the machines, tools, equipment and man power are brought at this location. This is generally applied where product produced is too fragile, bulky, or heavy to move. Examples of products manufactured under this layout are ships, aircrafts, missiles, houses etc.

2.2.5. Cellular Type Layout. In this, different items are analyzed and compared; then items with similar characteristics and processes are grouped to similar cells. Thus it is a hybrid form of product and process type layout. Here, firstly we have to define cells, and then arrange machines and accessories according to the type of process for particular type of product. Thus, there is reduction in the cost of material handling and the transportation of materials and equipment within the cells. It can produce varieties of products in small lots to gain market value.

3. Literature Reviews

Various researchers contributed various methodologies that can be applied to solve various layout problems. Some of the methods inferred from various researches are described as follows.

3.1. Systematic Layout Planning

It is efficient tool of layout planning for small and medium sized enterprises. It is concluded in four basic steps which are - analysis of factors, evaluation of parameters, search for efficient plans and last, select the best among all. PQRST (product, quantity, routing, services and timing) technique is used. Wiyaratn et al. (2010) [2] applied SLP method in an iron manufacturing company that decreased the material flow distance across the billet cutting process. Nakvi et al. (2017) [7] through his study paved a way to simplify the application of Systematic Layout Planning in the development of new layout through a case study.

3.2. BETROC

Babu et al. (2018) [1] developed an algorithm called BETROC (Better Alternative to Rank Order Clustering) based on ROC concept by King (1980) in an attempt to improve cellular manufacturing systems.

3.3. MADM method

It is an algorithmic approach to the layout design problems. It is abbreviated as ‘Multiple Attribute Decision Making’ method. Yang et al. (2007) [3] proposed two methods TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) and fuzzy TOPSIS to solve a plant layout design problem under the use of MADM (Multiple Attribute Decision Making) approach.

3.4. Workflow Calculation

Workflow can be stated as multiplication of material flow data and distance data. Determination of amount of workflow is termed as ‘Material Flow Efficiency’. Kovacs et al. (2017) [5] introduced mathematical model for workflow calculation that helped in improvement of the layout design. Work flow calculations are done to check and minimize the minimum material flow across the layout. Gould et al. (2015) [8] proposed a framework for ‘Material Flow Assessment in Manufacturing’ which increased the material flow efficiency in the current layout system. Balasundaram et al. (2016) [4] conducted case study on a job shop factory and reduced the material flow distance to improve plant layout and increase production.
3.5. Similarity Order Clustering
Onwubolu et al. (2018) [6] showed that ‘Similarity Order Clustering (SOC)’ algorithm is effective for solving cellular layout problems with different matrix densities. A similarity matrix is formed containing all the similarity coefficients between each machine which is further used to form groups or cells.

4. Present Work Findings (A Case Study)

4.1. About the company
“Bluebird light, lights up life!”- With this tagline Bluebird Lights Pvt. Ltd. manufactures LED lights of different types and specifications. The various products of this industry include white sparrow bulb, flood light, night light 0.5 W, falcon down light (round and square), eagle down light, dove glass panel (round and square), petrel press fit (round and square) and pelican tube light.
This industrial unit is located at Bluebird Light, 70, Jahangir Puri, Rajasthani Udyog Nagar, Delhi-110033. The main components of the LED lights manufactured comprises of heat sink, integrated circuit and chips, printed circuit boards (PCBs) and housing. This firm faced problem of inefficient material handling and unnecessary movements at the production line due to non-uniform flow of product that led to more throughput time for all the products being manufactured.

4.2. Problem
Initially, the firm produced limited products which are sparrow bulb, flood light and eagle down light. Later, due to the effect of Ujala Yojna Scheme launched by PM Modi; the demand in LED lights started rising. This led to many varieties of LED lights in the market. Thus, the firm decided to produce many varieties of LED lights. But this led to many problems like-

- Improper space utilization.
- Inflexibility in process due to inappropriate layout.
- Bottlenecks.
- Increased number of defects.
- Delayed delivery of products.
- Increased cycle time.
Thus, present layout system is revised to make it efficient in producing variety of products.

4.3. Objectives
The prime objectives of this case study is to revise the present layout system to-

- Increase capability to handle manufacturing of variety of products at the same efficiency.
- Increase feasibility of movement of man and material within the area.
- Reduce the material flow distance across various cells.
- Proper space utilization.
- Reduce overall delivery time.

The current layout of the manufacturing firm is shown in the fig.1.
4.4. Methodology

The concepts of Group Technology (GT) and Systematic Layout Planning (SLP) are used. GT is an efficient technique in which parts having similarities in design and production process are grouped together and manufactured in separate groups. The various similarities according to design can be attributed to dimensional similarity, material similarity, surface and geometry characteristics. Similarly the similar features in manufacturing can be attributed to the use of similar tools, tool holding devices, processes, sequence of operations and similar processing times. It enhances the space utilization and reduces material handling costs. The cellular type layout is an application of the group technology.

The product layout system is replaced by cellular type layout system. The tool chosen is ‘Activity Relation Diagram’.

An ‘Activity Relationship Diagram’ is a tabular means of displaying the closeness rating among all pairs of activities or departments. In this diagram, there are six closeness ratings which are assigned to

Figure 1. Current Layout
each pair of departments and nine reasons for those ratings. Here, we assigned five reasons according to our convenience.

The rating symbols include-
- A: Absolutely necessary
- E: Especially Important
- I: Important and Core
- O: Ordinary
- U: Unimportant
- X: Undesirable

The five reason codes we used are- ‘Convenience, Inventory Control, same personnel, Flow of parts and Communication’. To limit the choice of letters, a rule is implemented which is –
- A and X relationships ≤ 5%
- E ≤ 10 %
- I ≤ 15%
- O ≤ 20 %
- U about 50%

The analysis of Activity Relation Diagram is shown in fig.2.

![Activity Relation Diagram](image)

**Figure 2.** Activity Relation Diagram

On the basis of dependency of one process on another and number of cells to be allocated, the following type of layout is proposed shown in fig.3.
4.5. Results
The revised layout was proposed with the help of Systematic Layout Planning and Group Technology using Activity Relation Tool. The revised layout is a combination of cellular type layout and product layout. It resulted in:

- A 'U-shaped' layout system.
- Proper space utilization.
- Reduced movement of men and material within the area.
• Manufacturing of variety of products at the same time with same efficiency.
• On time delivery of product.
• Proper inspection and testing.

5. Conclusion
There are many factors which affect the efficiency and productivity of any manufacturing system. But, plant layout system is also an important factor in manufacturing system which many small scale firms neglect. There are many methods available which can be used to recreate efficient layout system like group technology, systematic layout problem and layout algorithms etc. However, cellular layout is proved to be more efficient than the product layout these days. Somewhere, combination of product and cellular type system is easy to adopt and implement without hindering the facilities very much.

A gap has been found that an efficient computerized system can be implemented that can automatically detect available space to be used according to the change in demand and variety of products. Also, it can show the percentage of utilized space from the total.

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