REDESIGNING OF MANUFACTURING LAYOUT FOR PERFORMANCE IMPROVEMENTS USING VIP PLAN OPT SOFTWARE

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Abstract

Plant Layout involves the spatial arrangement of equipment within the steel structure or building of a plant and considers the inter-connections through pipes and ducts as well as walks and vehicle transportation. An optimal layout has to ensure operability, adequate safety and an economic design. Industries have for many years been dealing with the problem of making batch production more efficient and responsive to changes in demand and technology. This paper presents a new and powerful concept known as Virtual Cellular Manufacturing (VCM). VCM helps in overcoming the problem of constant change in demand and part type by incorporating flexible production lines. The project 'OPTIMIZATION OF PLANT LAYOUT' is undergoing in PSG ROTARY MACHINE DIVISION, envisages optimize the plant area of shop floor using LEANCONCEPT.

Plant Layout is the arrangement of physical elements of facilities (or machines / equipment) which makes the products or service. Thus facilities layout is the overall arrangement of machines, men, material handling, service facilities, and passage required to facilitate efficient operation of production system.

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The major goal of plant layout optimization is to maximize profit and productivity by arrangement of the total 'manufacturing equation' – men, materials, and money in fulfilling in this goal.

This work addresses the optimization of the shop floor area in the Rotary Machine Division, with a focus on submersible and monoblock production lines. Hence the primary objective is to evolve and test the several strategies to eliminate wastage on shop floor. In this work systematic approach is suggested to implementation of lean principles to showcase the lean could be applied to optimize the plant layout effectively.

Use the value stream mapping gives the proper results to optimize the layout and the software VIP PLANTOPT is used to optimize the plant layout.

Keywords - process layout, product layout, virtual cellular manufacturing (VCM), value stream mapping (VSM), VIP plan opt and cellular layout.

I. Introduction

International competition relentlessly places pressure on manufacturing systems to be more effective. This is manifest by the fact that markets for consumer goods show an increase in variety and a decrease in product life cycle. Classical manufacturing systems such as process layout and product layout do not have the ability to respond quickly to these kinds of changes. In recent years, manufacturing organizations have been unable to cope with an increasingly fast changing market. Product life tends to be much shorter than in the past; this forces manufacturing organizations to increase responsiveness, increase flexibility, and shorten setup time and lower work-in-process inventory while maintaining an acceptable efficiency.

a) Process layout

Process layouts (also known as functional layouts) can be defined as a layout that groups similar activities together in departments of work centres according to the process or function that they perform. It is characterized by operations that serve different customers different needs. The equipment in a process layout is general purpose. Workers are skilled at operating the equipment in their department. The advantage of process layout is flexibility. The disadvantage is inefficiency. Process layouts are inefficient because jobs or customers do not flow through in an orderly fashion; backtracking is common and the workers may experience much "idle time" if they are waiting for more work to arrive from a different department. Material storage space in a process layout must be large to accommodate the large amount of in- process inventory. This inventory is high because material moves from work-centre to work-centre waiting to be processed. Finished goods inventory however is low because goods are being made for particular customers. Process layouts in manufacturing firms require flexible material handling equipment (such as forklifts) that can follow multiple paths, move in any direction, and carry large loads of in- process goods. All areas of the facility must have timely access to the material handling equipment. Process layouts in service firms require large aisles for customers to move back and forth and ample display space to accommodate different customer preferences.

b) Product layout

Product layouts (also known as assembly lines) can be defined as layouts that arrange activities in a line according to the sequence of operations that need to be performed to assemble a particular product. Each product should have its own "line". Product layouts are suitable for mass production or repetitive operations in which demand is steady and volume is high. Because of this product layouts are more autonomous than process layouts. The advantage of the product layout is its efficiency and ease of use. The disadvantage is its inflexibility. Each product must have a completely different assembly-line set up. The major concern in a product layout is balancing the assembly line so that no one workstation becomes a bottleneck and holds up the flow of work through the line. A product layout needs material moved in one direction along the assembly line and always in the same pattern. The most common material handling equipment used in product layouts is the conveyor. Conveyors can be automatic (at a steady speed), or paced by the workers. Aisles are narrow because material is moved only one way; it is not moved very far. Scheduling of the conveyors, once they are installed, is simple--the only variable is how fast they should operate. Storage space along an assembly line is quite small because in-process inventory is consumed in the assembly of the product as it moves down the assembly line. Finished goods inventory may require a separate warehouse for storage before they are sold.

c) Cellular layout

Greene and Sadowski provide the following definition of CM: ‘‘CM is the physical division of the manufacturing facility’s machinery into production cells. Cellular layouts attempt to combine the flexibility of a process layout with the efficiency of a product layout. Based on the concept of group technology (GT), dissimilar machines are grouped into work centers, called cells, to process parts with similar shapes or processing requirements. The layout of machines within each cell resembles a small assembly line. Production flow analysis (PFA) is a group technology technique that reorders part routing matrices to identify families of parts with similar processing requirements. Cellular layout has become popular in the past decade as the backbone of modern factories.

d) Virtual cellular layout

Virtual cellular layout combines the setup efficiency typically obtained by Group Technology (GT) cellular manufacturing (CM) systems with the routing flexibility of a job shop. Virtual cells allow the shop to be more responsive to changes in demand and workload patterns. Production using VCM is compared to production using traditional cellular and job shop approaches. Results indicate that VCM yields significantly better flow time and due date performance over a wide range of common operating conditions, as well as being more robust to demand variability. Dedicating equipment to families results in a loss of pooling synergy, and thus, poor shop performance. The Virtual Cellular Manufacturing (VCM) production control scheme creates the illusion of production using manufacturing cells without physically changing the process layout, yet still achieves the benefits of traditional CM system. A virtual cell is not identifiable as a fixed physical grouping of workstations, but as data files and processes in a controller. In other terms, a virtual cell is a logical grouping of resources within a controller. According to Kannan and Gosh (1996) virtual cells are “flexible routing mechanisms”.

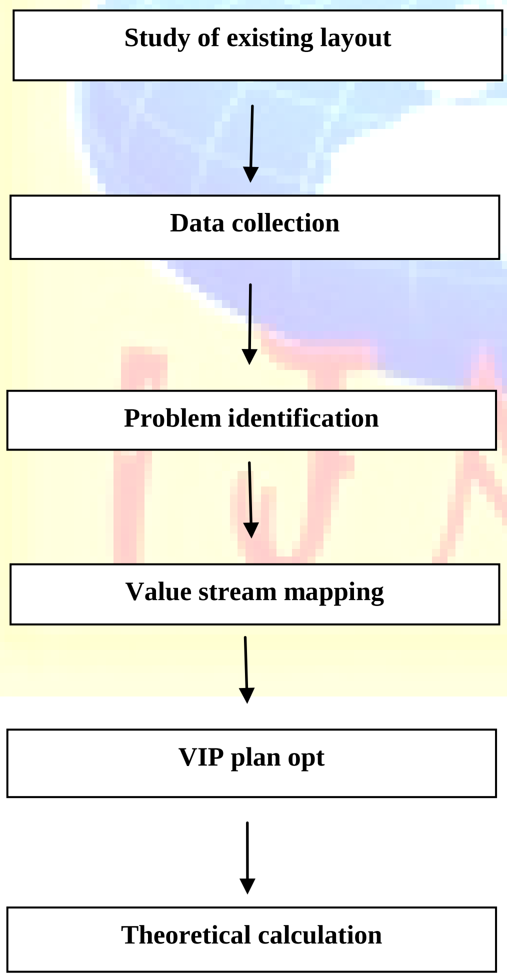
II. Value stream mapping

Value stream mapping is a set of methods to visually display the flow of materials and information through the production process. The objective of value stream mapping is to identify value-added activities and non-value-added activities. Value stream maps should reflect what actually happens rather than what is supposed to happen so that opportunities for improvement can be identified. Value Stream Mapping is often used in process cycle-time improvement projects since it demonstrates exactly how a process operates with detailed timing of step-by-step activities. It is also used for process analysis and improvement by identifying and eliminating time spent on non-value-added activities.

III. VIP PLAN OPT software

PLANOPT (floor-PLAN layout Optimization) represents a general purpose layout optimization algorithm. VIP-PLANOPT (Visually Interfaced Package of PLANOPT) is a powerful software package developed to produce high-quality optimal layouts for small, medium and large-sized problems involving UNEQUAL-AREA rectangular blocks or "modules". The term Layout Optimization implies the placement of a given number of such modules at their optimal locations in the Euclidean plane without any overlaps. It is a challenging area of research in various fields of engineering. In the field of industrial engineering the problem is usually referred to as "Facility Layout" problem. Several other terms like "Plant Layout", "Machine Layout", "Floor-plan Layout", etc. refer basically to the same optimization problem.

IV. METHODOLOGY



V. Existing layout

The industry chosen for analysis of layout is **PSG Industrial Institute, Coimbatore.** PSGII's main products are Pumps and Motors for agricultural, domestic and industrial applications. The production line that produces the following two components is specifically analyzed in the perspective of layout:

1. R-type submersible pump
2. M-type submersible pump

Then we have made a case study on PSG Industrial Institute. We have analyzed the existing layout as shown in the fig .1.

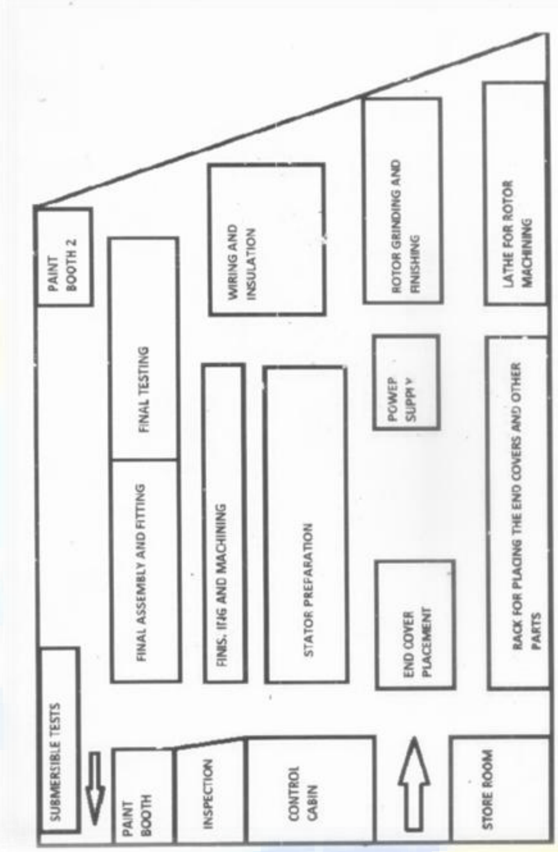


Fig.1 Existing layout

VI. Data collection

Table 1.Machines at running condition

Initially we have analyzed the number of machines in the industry which are in running condition as shown in the table 1.

MACHINE TYPE	NO. OF MACHINES
Driller	2
Lathe	2
CNC	1

MACHINE TYPE	NO. OF MACHINES
Driller	14
Milling	3
CNC	1
Lathes	17
Grinding	8
Shearing M\C for Insulation	1
Broacher	1
Jig Boring Machine	1

Table 2.Machines at idle condition

DESCRIPTION	AREA OCCUPIED (m^2) (per machine)

Lathe	3
Drilling machine (Portable)	0.7
Drilling machine (Heavy)	4.23
CNC machine	3.9
Broaching machine	3.1
Shearing machine	2.8
Grinding machine	2.91

Table 3.Space study

And then there are few machines which are in idle condition as shown in the table 2. And also we have made space study on the industry as shown in the table 3.

- Total area of the plant – 2840m^2.
- Area under usage – 2550m^2.
- Area under idle (pathway and others) – 210m^2.
- Area not in use (idle machines) – 80m^2.

VII. Problem identification

a) Observed problems

- Insufficient job completion time.
- More Inventories.
- Lack of clean ground.
- More no of leftovers.

b) *Required Alternatives*

- Reduction in wastage by using scrap controllers.
- Possible automation.
- Rearranging the flow of work.

VIII. VIP PLAN OPT

VIP-PLANOPT has a powerful visual interface with tips to help the user. Most users learn to use the program without any manual as they try VIP-PLANOPT on simple problems. Despite the efforts to make VIP-PLANOPT a self-learning tool supported by this manual, users may have questions while modeling a real-world problem. Technical support is available to all users of VIP-PLANOPT. They are encouraged to ask for assistance whenever they have any such questions. This chapter describes the primary input required to model a problem using the main input window of VIP-PLANOPT.

STEP 1 --- Using **Create** option the collected length and width of each and every machine can be inputted

STEP 2 --- Select Anchored or Soft option

STEP 3 --- Using **Module padding** option the space around the each and every machine can be inputted

STEP 4 --- Using **Boundary shape** option, the actual and main constrain of the entire plant can be inputted as rectangle.

STEP 5 --- Using **Flow Matrix** option the input transport and output transport cost can be inputted.

STEP 6 --- Using **Optimize** option we get the optimal layout of the plant.

First we have to give the dimension for each and every machine of industry in the software as shown in the fig .2.

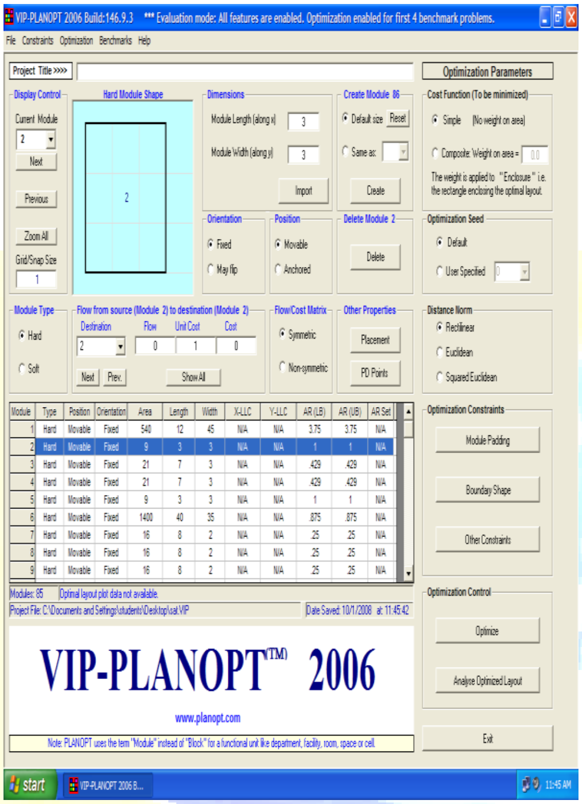


Fig.2 Main input window of VIP PLAN OPT

Next we have to decide the boundary shape for each and every machine. And then we have given those machines as movable type in order to optimize it. We have to give power supply unit as anchored type. And then we are required to give the free space needed around each and every machine using module padding option as shown in the fig.3.

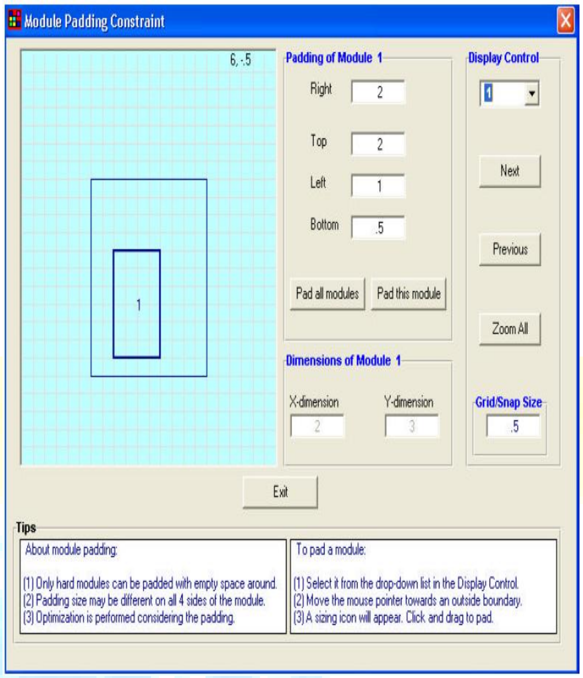


Fig.3 Module Padding Input Window

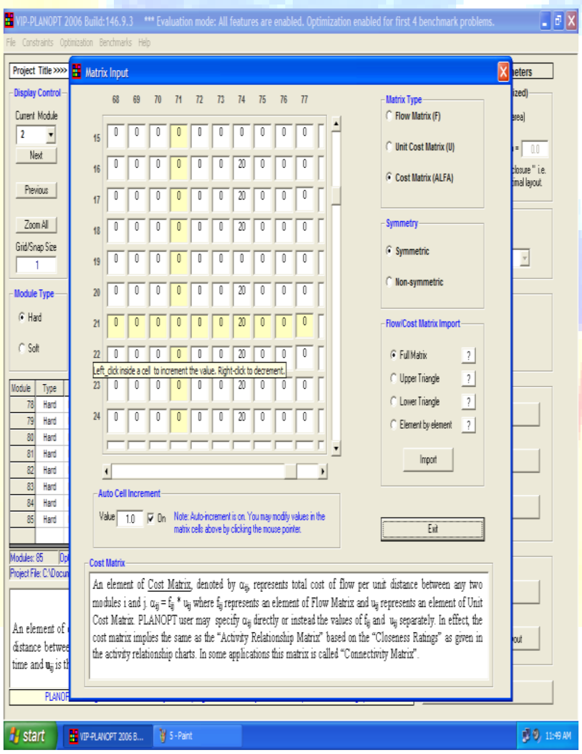


Fig.4 Flow matrix input window

After that we have to analyse flow of materials between the machines. And also we have calculated the unit cost required for the single product. We have to give the number of products to be moved and unit cost for the transportation in flow matrix option as shown in fig.4.

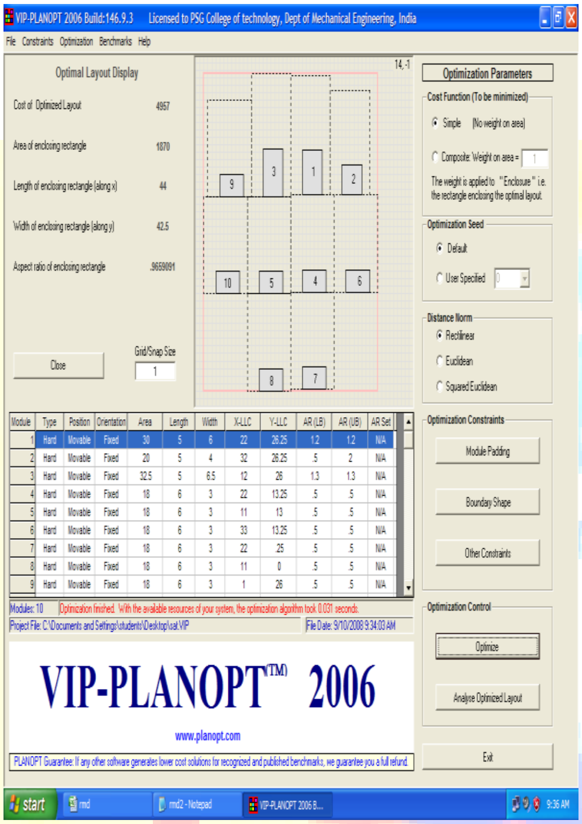


Fig.5 Optimal Layout Window

Finally, we have to optimize our existing layout in order to minimize the cost. Software results show that some unwanted transport and space occupation leads to high cost. If we eradicate those wastes we can easily minimize cost. The final layout optimized by software is shown in fig.5. This software have been validated by theoretical calculation.

IX. Theoretical calculation

$$\mathbf{F_2} = \sum_{i=1}^{n}\sum_{j=1}^{n} f_{ij}\, u_{ij}\, d_{ij}$$

or,

$$\mathbf{F_2} = \sum_{i=1}^{n}\sum_{j=1}^{n} {}_{ij}\, d_{ij}$$

Where, f_{ij} – Flow matrix between i and j module

U_{ij} – Unit cost matrix

D_{ij} – Distance matrix

i,j are machines.

d_{ij} = | x_i x_j | +| y_i y_j |(Rectilinear form)

Machine	Original cost(Rs)	Modified cost(Rs)	Cost of saving (Rs)
Radial Boring Machine	2778.00	2407.24	370.76
Milling Machine	4343.20	1370.12	2973.08
Rotor Balancing Machine	2000.16	1666.80	333.36

Slotting Machine	3333.52	1777.92	1555.56
Mechanical and Electrical Shearing Machine	3147.72	1573.86	1573.86
		TOTAL	6806.66

Table 4.Theoretical Calculation

For 100 Products **Rs 6806.66**

For 500 Products **Rs 34033.30**

We have theoretically calculated cost is shown in the table 4.

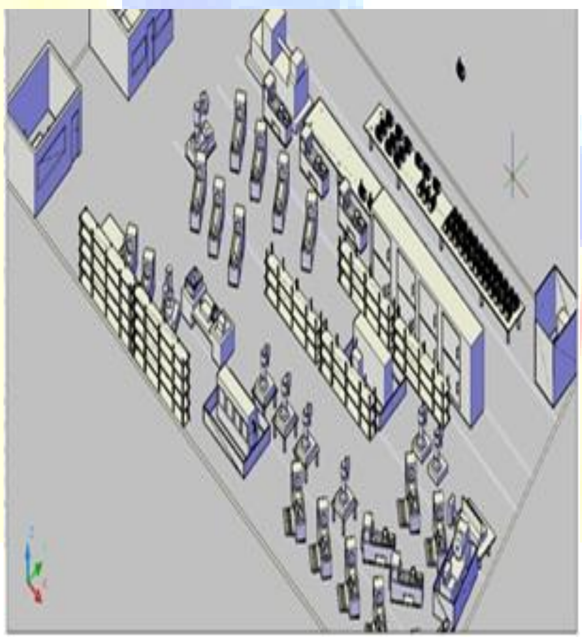


Fig.6 Modified plant layout

Finally we have designed our modified layout of the industry using AutoCAD software is shown in fig.6.

X. Conclusion

This paper enables the user to include both qualitative as well as quantitative aspects of layout. After implementing this layout in the industry, the material movement in the production line is decreased from1251 m to 713 m which shows a reduction of 43%.The machines in the existing process layout are underutilized and it is increased by 38.89 % in modified layout. The results obtained from the VIP PLANOPT software shows that, modified layout gives better output than the existing layout. Lean techniques are basically scientific approaches that continuously improve quality, speed, cost and flexibility by eliminating waste or non-value added activities. The work presented here was carried out by adapting group technology, cellular manufacturing system, and systematic layout planning, which are basically scientific approaches and part of lean techniques that led to improve the quality, speed, cost and flexibility.

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