

# DEVELOPMENT OF PLANT LAYOUT USING SYSTEMATIC LAYOUT PLANNING (SLP) TO MAXIMIZE PRODUCTION – A CASE STUDY

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**Abstract-**The objective of this research is to study the existing plant layout of a nacelle production unit and to design a lean plant layout using SLP (Systematic Layout Planning) to increase its productivity. Analysis of the existing plant layout was made by studying aspects like flow of materials, activity relationships and space requirements. New plant layout alternatives were designed and compared to the existing layout. The new plant layout finally selected showed a significant decrease in the distance of material and work flow travel and resulted in increasing the productivity of the unit.

**Index Terms-** Activity Relationship Chart, Facility layout, Lean, Systematic Layout Planning

## I. INTRODUCTION

Plant layout refers to 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 shipment of the finished product.

Plant layout optimization is a crucial step towards making an industry more lean. It helps to eliminate non-value adding work caused due to poor layout design and management. The manufacturing throughput time is also greatly reduced, therefore decreasing productivity and increasing costs. Previous case studies have shown the practical significance of using SLP in improving productivity and utilization of space in a production unit.

Manufacturing industries are always under pressure from their shareholders to improve productivity. They are not only being compared with their competitors, but also within their own group of companies. An organization can therefore not just look at the competition on their local market, but it has to compare itself with factories all over the world. This case study was carried out at a nacelle production unit having a process type layout.

The problems faced by the unit are more time and cost of manufacturing as a result of an inefficient plant layout.

It is seen that the distances travelled by components and personnel during the manufacturing process is a cause for delays in manufacturing. Excess movement and transport is also a cause for extra costs and wasted energy. With these problems in mind, the SLP technique is applied to

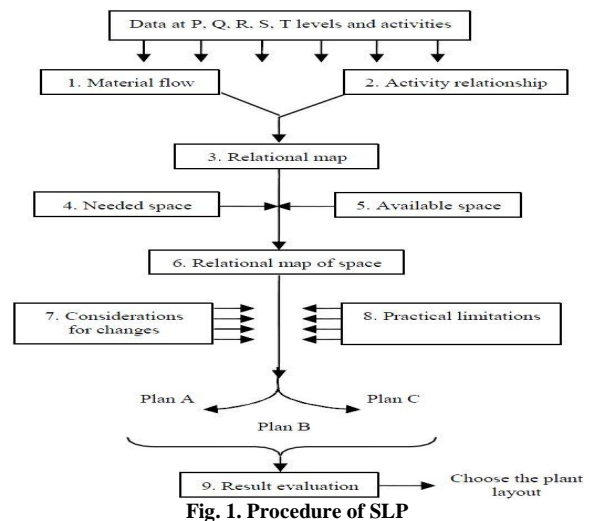


Fig. 1. Procedure of SLP

Optimize the existing layout and reduce the wastes. The basic analysis of the existing layout is done by establishing the relationships of the different activities in the layout. Space required for each activity area and the necessary equipment is determined. After analyzing the existing layout, a new layout is designed. A final layout plan is selected after making necessary adjustments and evaluations in accordance with any practical limitations. The SLP technique gives a good result in improving work flow during the manufacturing process.

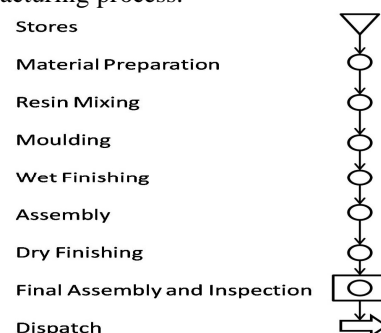


Fig. 2. Process Flow Chart

## II. BASIC OUTLINE OF LAYOUT DEVELOPMENT

The tasks carried out in the SLP method used broadly falls into two phases; analysis and design. Fig. 1. shows the general procedure of SLP in the form of a block diagram.

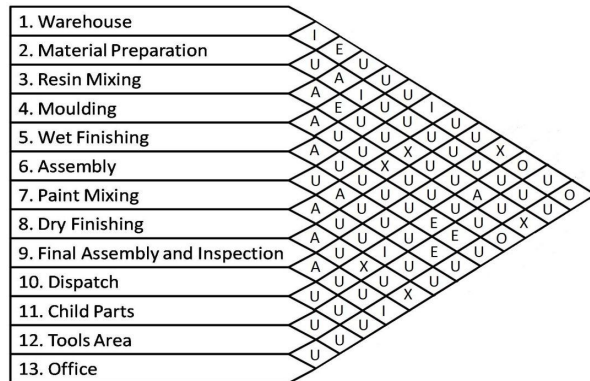


Fig. 3. Activity Relationship Chart

## III. ANALYSIS OF THE EXISTING PLANT LAYOUT

This step in SLP deals with the gathering of all the information and data that is required to facilitate the design of an optimized plant layout. There are two types of products being manufactured namely, nacelle and nose cone. The nacelle and nose cone are produced in the same quantities and are delivered as a set.

Table I  
Distances travelled in the existing layout

Process	From	To	Nacelle (m)	Nose Cone (m)
1. Material Preparation	Warehouse	Material preparation	57.25	57.25
	Warehouse	Child parts	141	141
2. Resin Mixing	Warehouse	Mixing cage	86.8	86.8
3. Moulding	Material preparation	Main mould	60.45	70.5
	Resin mixing	Main mould	26.25	23
	Resin mixing	Child parts	60.5	60.5
	Main mould	Mould storage	132	59.5
4. Wet Finishing	Mould storage	Wet finishing	129	37.5
	Resin mixing	Wet finishing	47.5	103
	Child parts	Wet finishing	137	30.5
	Tools area	Wet finishing	61	112.5
5. Assembly	Wet finishing	Pre - assembly	24.5	-
	Pre - assembly	Assembly	69.5	-
	Wet finishing	Assembly	-	101.5
	Tools area	Assembly	122.5	93
6. Dry Finishing	Paint mixing	Dry finishing	51	58
	Paint mixing	Child parts	76.5	76.5
	Assembly	Dry finishing	25	15
7. Final Assembly and Inspection	Dry finishing	Final assembly	42.75	50
	Tools area	Final assembly	125	-
8. Dispatch	Final assembly	Dispatch	14	14
Total			1489.5	1190.05

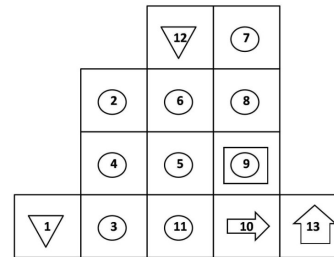


Fig. 4(a). Dimensionless Block Diagram of Layout 1

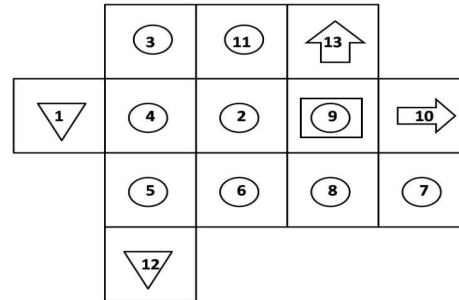


Fig. 4(b). Dimensionless Block Diagram of Layout 2

### A.Flow of Materials

The analysis is done on the flow of materials for the two products being manufactured. The sequence of operations performed in the manufacturing process forms the basis for the analysis of flow. Fig. 2. shows the process chart which is applicable to both nacelle and nose cone since the steps in their processes are largely the same.

Table II  
Relationship between equipment size and work area

Department	Equipment Type	Number of Equipments	Equipment Area (m <sup>2</sup> )	Total Working Area (m <sup>2</sup> )
1. Material Preparation	Cutting table	6	72.82	548.1
	Foam chamfer machine	1	1.96	
	Mat roll pulling trolley	2	1.74	
	Storage bins	25	32.67	
	Storage racks	12	27.74	
2. Resin Mixing	Container stand	2	3.48	71.4
	Mixing cage	1	8.88	
3. Moulding	Main moulds	7	487.84	1400.5
	Mould jigs	3	18.3	
	Movement trolleys	12	304.74	
4. Wet Finishing	-	-	-	819.07
5. Assembly	Assembly fixtures	3	80.62	683.40
	Ladders	3	18	
	Stands	3	13.5	
6. Paint Mixing	Mixing room	1	33.45	85.43
7. Dry Finishing	Paint booth	1	55.64	667.04
8. Final Assembly and Inspection	Work stands	3	111.78	347
9. Child Parts	Cutting table	1	3.3	507.33
	Moulds	20	150.61	
	Storage racks	3	16.78	
10. Tools Area	Tool cages	4	48.19	202.94
	Storage bins	11	43.83	
11. Office Area	Office rooms	3	62.31	135.29

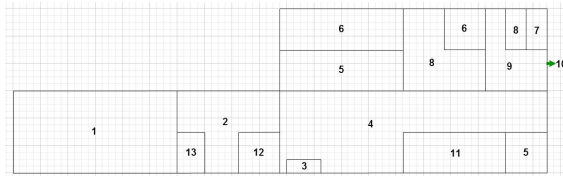


Fig. 5(a). Plant Layout : Original

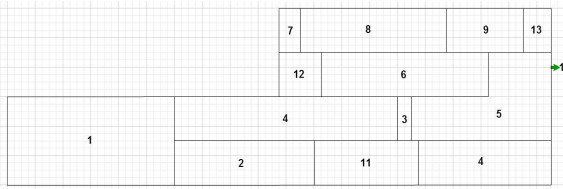


Fig. 5(b). Plant Layout : Proposed Layout 1

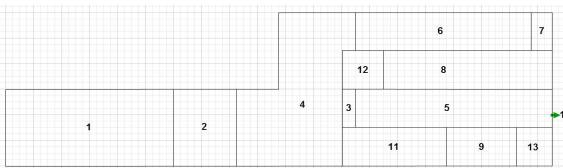


Fig. 5(c). Plant Layout : Proposed Layout 2

### B. Motion and Transportation

The term motion is used for the movement of people, and transportation for the movement of objects. Quantitative data was obtained to calculate the total distances travelled in terms of motion and transportation during the manufacturing process.

Table I displays the data for both the nacelle and nose cone for the existing plant layout. It presents the from-to distances between different locations for each major process in their manufacturing. The data serves as a baseline and is useful in determining the degree of closeness necessary between different departments for material interaction. Efforts are made in layout design to place the departments having more material movement close to each other to minimize material handling.

It was seen that movement of raw materials was carried out over long distances. Also, the flow of work was not optimum due to disjointed department areas.

### C. Activity Relationship Chart

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.

They are defined as A: Absolutely necessary, E: Especially important, I: Important, O: Ordinary, U: Unimportant and X: Undesirable.

To make the chart we were required to consider qualitative aspects like flow of material, ease of supervision and unsafe conditions. This was discussed with the work team leaders and supervisors to help

identify the relative importance of having one department near to other.

The relationship chart as shown in Fig. 3. was prepared after considering both quantitative data of distances travelled as well as the qualitative data collected from working personnel.

### D. Space Requirements

It is important to also consider the space requirements of each department area in relation with the work equipments. The equipment type and the space they occupy is listed alongside their respective departments in Table II. This data helped in the design phase of the layout planning when relocating the departments.

## IV. DESIGN OF NEW AND ALTERNATE PLANT LAYOUTS

The data collected from the analysis phase of the layout planning was used in proposing new and alternate plant layouts which were checked for optimum flow of work through the processes.

### A. Dimensionless Block Diagram

The dimensionless block diagrams in Fig. 4. are prepared based on the relationship chart and serves as a basis for two new alternate layouts. The departments are numbered in the same manner as seen in the ARC. The block diagram ignores space and building constraints, and gives us a better idea for designing the optimized layout.

### B. Proposed Layout

The SLP technique resulted in two new alternate plant layouts after taking into consideration any practical limitations and constraints. Fig. 5. shows the original layout as well as proposed layouts 1 and 2, drawn to scale. Each square in the figure grid represents an area of 6.25 m<sup>2</sup>.

Table III  
Distances travelled in the optimized layout

Process	From	To	Nacelle (m)	Nose Cone (m)
1. Material Preparation	Warehouse	Material preparation	64	64
	Warehouse	Child parts	107	107
2. Resin Mixing	Warehouse	Mixing cage	121	121
3. Moulding	Material preparation	Main mould	33.5	90
	Resin mixing	Main mould	42	42.5
	Resin mixing	Child parts	31	31
	Main mould	Mould storage	88	79.5
4. Wet Finishing	Mould storage	Wet finishing	31.5	31.5
	Resin mixing	Wet finishing	41.5	41.5
	Child parts	Wet finishing	72.5	72.5
	Tools area	Wet finishing	78.5	78.5
5. Assembly	Wet finishing	Pre - assembly	74	-
	Pre - assembly	Assembly	40.5	-
	Wet finishing	Assembly	-	38
	Tools area	Assembly	37.5	79
6. Dry Finishing	Paint mixing	Dry finishing	47	47
	Paint mixing	Child parts	75	75
	Assembly	Dry finishing	36	51.5
7. Final Assembly and Inspection	Dry finishing	Final assembly	57	57
	Tools area	Final assembly	83.5	-
8. Dispatch	Final assembly	Dispatch	36.5	36.5
		Total	1197.5	1143

## V. RESULTS OF THE LAYOUT DEVELOPMENT

The proposed layout 1 was finally selected as the new optimized plant layout. With the new layout all disjoined department areas were made as one and efficient material flow was achieved. Table III shows the total overall distances travelled in the optimized layout plan. The total distance travelled for nacelle is reduced by 292 m and for nose cone by 47.05 m. Therefore in the optimized layout, the total distance reduced in the manufacturing of one set of nacelle and nose cone is 339.05 m. By the application of SLP for the design of an optimized plant layout we were able to reduce the wastes due motion and transportation, therefore increasing the productivity of the plant.

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