Optimization of Machining Facility Layout by using Simulation: Case Study

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Abstract - *In today's competitive world it is important to deliver right quality and right quantity of material in the scheduled time. To serve this cause there is need to improve existing technologies and maximize effective use of resources of manufacturing. Facility Layout is one of the important aspects in achieving this goal. Proper analysis of available data, forecasting, use of expertise and technology is one of the keys for solving the problem. We have proposed optimized layout to a machining vendor of agriculture equipment and engine manufacturers. This work understands the existing products, processes and their requirements. After collection and analyzing the data research of optimal solution is done. Then Systematic Layout planning process is applied to create possible alternatives of facility layout. Then the layout alternative is chosen and simulated using FlexSim Simulation software. The outcome of simulation is compared with existing system performance. This course of work can be referred in solving FLP by using simulation software.*

Key Words: **Facility Layout Problem (FLP), Systematic Layout Planning (SLP), Simulation**

1. INTRODUCTION

Determining the physical organization of a production system is defined to be the Facility Layout Problem (FLP). Where to locate facilities and the efficient design of those facilities are important and fundamental strategic issues facing any manufacturing industry. Its claimed that from 20 to 50 percent of the total operating expenses in manufacturing are attributed to materials handling costs. Effective facilities planning could reduce these costs by 10 to 30 percent annually. For FLP, the most common objective used in mathematical models is to minimize the materials handling cost, which is a quantitative factor. Qualitative factors such as plant safety, flexibility of layout for future design changes, noise and aesthetics can also be considered. [1]

The most crucial element that affects efficiency of a production process is the facilities layout. A good layout keeps costs low and reduces unnecessary material handling while maintaining the product flow through the facility. Improving the layout also increases the machine utilization that enhances the machining capacity of the shop floor. Quite often, the management feels the need of redesigning plant layout even when the things are apparently going smoothly for the company. One of the reasons for designing a new layout may be improving the performance of the existing plant. Upgrading the facility by replacing old facility with more advanced machinery is also necessitated many a times. In both the cases the performance measures being targeted for improvement need be identified clearly. [2]

In the case of machining facility taken for case study has some of the major reasons which are directing us for the layout change. The existing layout is based on process layout theory. At the initial stages of foundation of the company this decision was more appropriate considering the uncertainty about repeat order, low production volumes, wide variety of products to machine. However, with time the customers settled and grown to substantial production volumes along with precise requirement schedules and forecasts. Thus, at the present situation the facility produces medium product mix, consistent production volumes. Due rising pressure of cost reduction and need of improvement in effective utilization of resources the firm requires certain changeovers and necessity to maximize the capacity with new equipments in future. To accommodate these equipments there is need to remove unutilized machines. Considering strategic requirements, medium product variety, consistent production volumes layout change can be a solution to achieve the desired goals.

Here analysis of existing layout is made with the help of FlexSim Simulation Software student version. The analysis of existing systems gives us idea to opt for new facility layout theory. Here the alternative generated by using the Systematic Layout Planning (SLP) methodology. The alternative layout is analyzed using FlexSim simulation software. The results of existing layout and proposed layout are compared in terms of Distance traveled for material movement, Time required to start first jobs machining, Throughput Time etc.

2. LITERATURE REVIEW

S. P. Singh [1] et al studied Qualitative factors such as plant safety, flexibility of layout for future design changes, noise and aesthetics can also be considered. For FLP, the most common objective used in mathematical models is to minimize the materials handling cost, which is a quantitative factor. The focus of this review work is on the facility layout of industrial (manufacturing) plants, which is concerned with finding the most efficient arrangement of ‘n’ indivisible facilities in ‘n’ locations. Minimizing the material handling cost is the most considered objective but many practitioners gave qualitative and quantitative objectives for FLP. Reduced material movement lowers work-in-process levels and throughput times, less product damage, simplified material control and scheduling, and less overall congestion. V.A Deshpande et al [3] in their work have done a real-life case study involving relayout problem. In this case study, the authors investigated that the constraint of inadequate space has increased the material handling cost by increased material flow. In this paper the authors have used improvement algorithm (CRAFT) and travel chart to solve the facility layout problems related to transmission assembly line. Y. Liu et al [4] have studied and applied SLP in a logistic centers layout. Systematic layout planning (SLP) has been widely applied to the production system, but not to the service system. Combined with the goals, influencing factors, and conditions of logistics center layout, this paper probes into the application of SLP to the layout of the rapidly increasing logistics centers in large- and medium-sized cities in recent years. Mahesh R. Korde et al [5] have made a design and development of simulation model. The course this of this work is to investigate the possible improvements in the blanking plant layout which manufactures automotive parts. Wisitsree et al. [6] designed the plant layout of iron manufacturing based on SLP for increased productivity, the result showed the new plant layout significantly decrease the distance of material flow from billet cutting process until keeping in ware house. Therefore, plant layout is possible way to improve the production. Hence, the first step for plant layout improvement should be started with identifying the problems of the current plant layout in order to maximize the productivities at the minimized investment. X. Zhu et al [7] have made a FlexSim based Optimization for the Operation Process of Cold- Chain Logistics Distribution Centre. This paper makes adjustments for the system to get a better result which makes efforts to give a reference for the modelling and simulation for the operation process of other cold-chain logistics distribution centers. Maina Eliud C., et al [8] in their paper aims to study and improve the facility layout of a manufacturing company using Muther’s systematic layout planning procedure (SLP) for increased productivity and space utilization. A multi-criteria decision-making tool is then proposed and used to evaluate the developed alternatives which are compared with the existing layout. The SLP method derives an improved layout that improves flow of materials, utilizes space effectively, and is flexible.

Filippo De Carlo et al [10] In their work have compared the results of a fashion manufacturing line re-layout by analysing the current situation with the solutions provided them. In order to evaluate the effectiveness of each solution, the different alternatives were compared with the help of a discrete event simulator, analysing productivity, transportation times and costs. The result of the case study showed a slight advantage with the lean approach in considering such efficiency indicators.

Anucha Watanapa et al [9] have done research that presents plant layout and process of pulley production. The alternative plant layouts have been designed by SLP method. On the basis of SLP method, the sequence of work and work flow of pulley production was rearranged, which the rearrange layout can decrease flow of material, resulting in significance increased production. In additional, the reducing of material handling cost is observed.

3. PROCEDURE TO SOLVE THE PROBLEM

In this section we will discuss the procedure used to solve the facility layout problem. Here analysis of existing layout is made with the help of thread diagram and FlexSim. The analysis of existing systems gives us idea to opt for new facility layout theory. Here the alternative generated by using the Systematic Layout Planning (SLP) methodology. The alternative layout is analyzed using FlexSim simulation software.

The data collection is done in order to comply the requirements of SLP methodology. Here we measured the space occupied by each machine in the machining facility. The same was represented on CAD software AutoCAD. This was initial input consisting of existing layout. We studied the product mix and product quantity being machined in the machining facility.

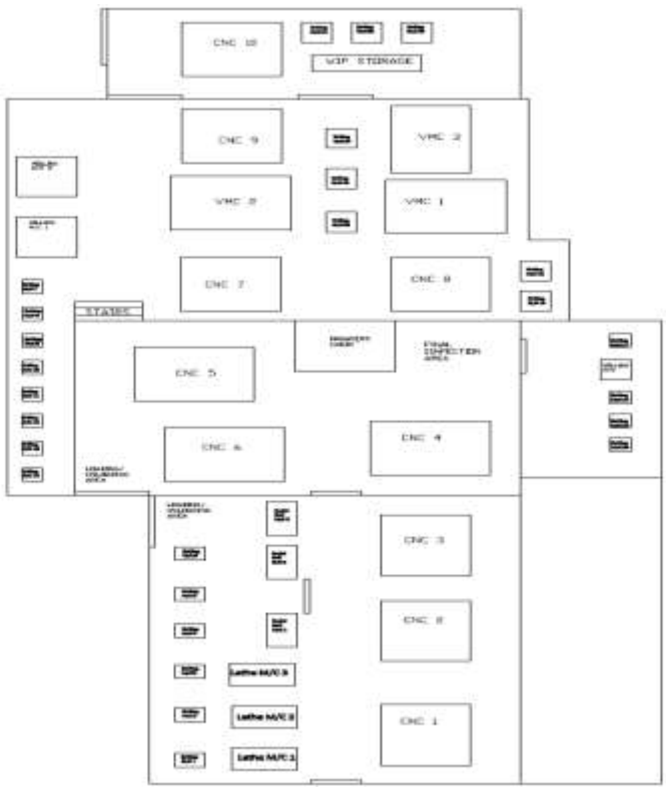

Fig. 1 Existing Facility layout

The data were collected and the number of equipments for machining was counted in terms of the direction for raw materials and product. The operation process chart, flow of material and activity relationship chart were used in analysis. The problem of the facility was determined and analyzed through SLP method to plan the relationship between the machines and the area. The framework of SLP is shown in Fig. 2.

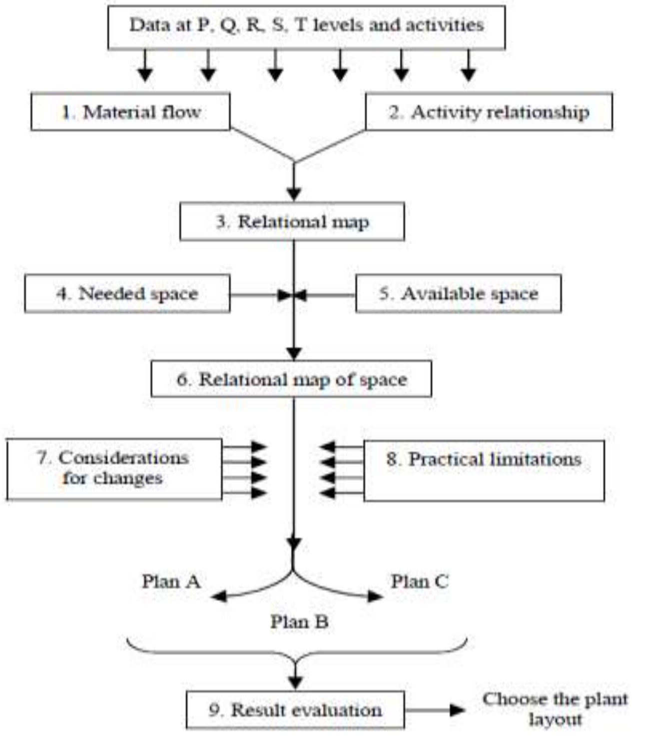

Fig. 2 Framework of SLP [13]

Sr No	Product	Qty per day	Routing
1	Piston	110	49-24-32-19-51-50
2	Retainer Bearing	220	49-13-14-8-11-5-51-50
3	Guide release	210	49-18-17-23-2-9-51-50
4	Bearing Housing	60	49-29-30-25-26-51-50
5	Retainer Bearing 2	360	49-13-53-8-11-51-50
6	Retainer Pin	160	49-16-53-50
7	ARM	250	49-28-43-25-27-51-50
8	Pedal	150	49-28-25-51-50
9	Guide release 2	270	49-52-18-4-12-51-50
10	PPCD	320	49-20-54-5-52-50

Table No. 1 From to Chart

Where the machines are specified as per following table. The Numbers are assigned for identification and representation purpose.

No.	Equipment
1	Drilling M/C 1
2	Drilling M/C 2
3	Drilling M/C 3
4	Drilling M/C 4
5	Drilling M/C 5
6	Drilling M/C 6
7	Lathe M/C 1
8	Lathe M/C 2
9	Lathe M/C 3
10	Radial Drill M/C 1
11	Radial Drill M/C 2
12	Radial Drill M/C 3
13	CNC Lathe 1
14	CNC Lathe 2
15	CNC Lathe 3
16	CNC Lathe 4
17	CNC Lathe 5
18	CNC Lathe 6
19	CNC Lathe 7
20	CNC Lathe 8
21	Drill M/C 15
22	Drill M/C 16
23	CNC Lathe 9
24	CNC Lathe 10
25	Drill M/C 21
26	Drill M/C 22
27	Drill M/C 23
28	cnc VMC 1
29	cnc VMC 2
30	cnc VMC 3
31	Drill M/C 24
32	Drill M/C 25
33	Drill M/C 26
34	Drill M/C 7
35	Drill M/C 8
36	Drill M/C 9
37	Drill M/C 10
38	Drill M/C 11
39	Drill M/C 12

40	Drill M/C 13
41	Drill M/C 14
42	Milling M/C 1
43	Milling M/C 2
44	Milling M/C 3
45	Drill M/C 17
46	Drill M/C 18
47	Drill M/C 19
48	Drill M/C 20
49	Raw material storage
50	Ready For Dispatch Zone
51	Final Inspection Area
52	CNC Lathe 11
53	CNC Lathe 12
54	cnc VMC 4

Table No. 2 Machines List

The product flow and the weightage of material movement is shown by following activity relationship chart. This chart has been further used to propose new layout.

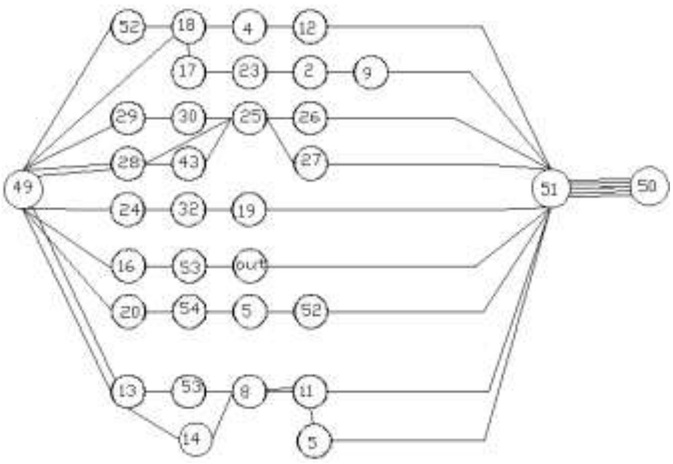

Fig. 2 Activity Relationship chart

Based on the data such as product, quantity, route, support, time and relationships between material flow from-to chart and activity relation chart are displayed. From the material flow and relationship activity in machining facility, the relation between each operation unit can be observed. Then the outcome of SLP was analysed using FlexSim simulation software.

4. RESULTS

The above steps of SLP was converted into the relational map of space. Further this was applied with the practical constraints and changeover considerations. The output of the SLP can be expressed with the help of following proposed layout (Fig. 3). Simulation using FlexSim Software were done for fast moving products considering their actual process flow, processing time, set up time on the exact location coordinate based simulation model. Here some assumptions were assigned in order to achieve the accuracy with the actual performance of the machining facility. The simulation has been done considering one component machining at a time. The same assumptions and constraints are applied to the proposed facility layout simulation. The results of the simulation for case study machining component piston components are shown in Table No 3.

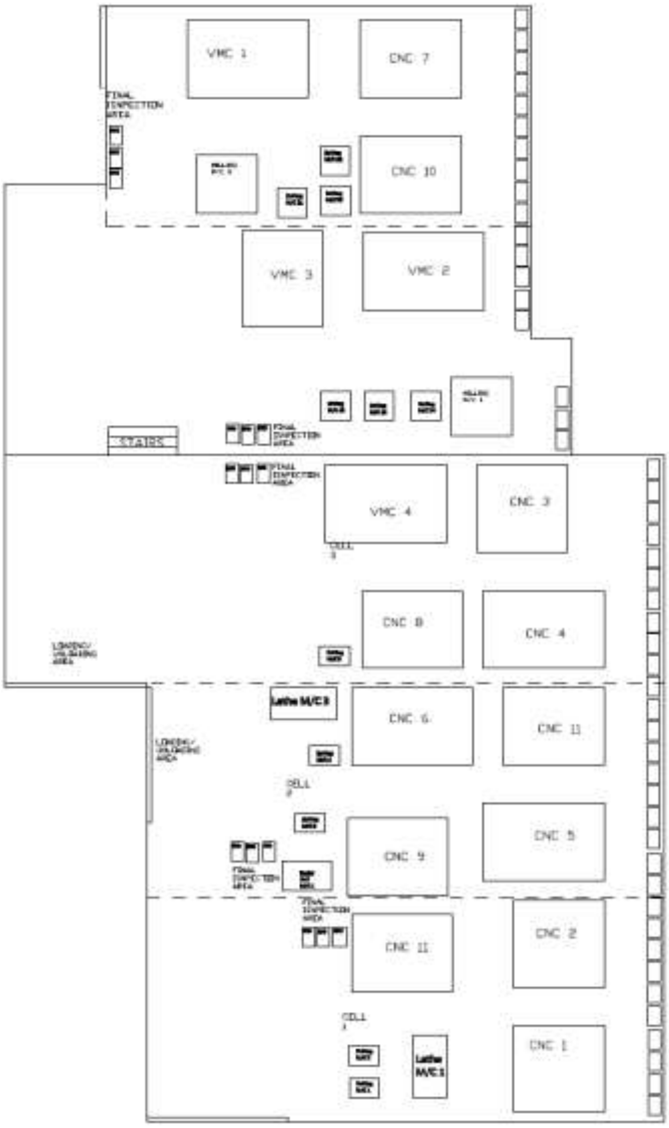

Fig. 3 Proposed Facility Layout Alternative

Sr No	Parameter	Existing Layout	Proposed Layout	% Change
1	Distance traveled for material movement (meter)	191.72	113.78	40.65
2	Time required to start first jobs machining (seconds)	285	100	64.91
3	Throughput Time Trial Run (Hr:Min:Sec)	00:10:29	00:09:41	7.63
4	Throughput Time Production (Hr:Min:Sec)	07:09:14	06:56:57	2.86

Table No 3 Simulation Results for Piston

Similarly, the simulation has been done for the machining of component retainer bearing.

Sr No	Parameter	Existing Layout	Proposed Layout	% Change
1	Distance traveled for material movement (meter)	84.95	29.63	65.12
2	Time required to start first jobs machining (secands)	316	9	97.15
3	Throughput Time Trial Run (Hr:Min:Sec)	00:12:11	00:11:20	6.98
4	Throughput Time Production (Hr:Min:Sec)	05:14:03	04:36:09	12.07

Table No 4 Simulation Results for Retainer Bearing

5. CONCLUSIONS

The quantitative and qualitative outcomes from this course of work can be seen though achievement of following objectives by implementation of proposed layout.

1. Reduction in throughput time about 3% to 12%.
2. Significant Reduction in material movement distance by 50% to 70%.
3. Reduction in idle time of machines caused by waiting due to unavailability of raw material.
4. Simplified and short material flow
5. Improved control over production activity due to reduced cell size and reduced material flow.
6. Lower costs of incurred due to material handling and reduction in unnecessary material handling time and efforts while maintaining the product flow through the facility.
7. Proposed facility layout designed with lesser machine tools assures the same production output in idle running conditions.
8. The newly vacant space in proposed layout complies with the strategy of management to upgrade and improve the capacity by addition of new machines.

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