Optimization of Manufacturing Plant Layout Using Systematic Layout Planning (SLP) Method

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Abstract. The plant shop floor layout of a company manufactures gear bush is analysed in this study along with the application of the systematic layout planning (SLP) technique as a means of resolving the issue.The interaction between machines, operational tasks, and material flow is taken into consideration when deciding where each machine should be placed. The relationship between machines and plant area has looked into in detail, together with the activity relationship chart, process chart and plant layout. The proposed production shop floor plan was designed using the SLP technique, and the performance of the proposed layout in terms of material travelling distance, travel time, and labour cost was compared to that of the existing layout. The measures included the layout's actual sizes, the activities between machines, the separation between machines, and the material travelling between machines in the plant. The total distance travelled by the material is reduced to 799ft. from 1227ft., production is doubled and ideal time is eliminated.

Keywords: Systematic Layout Planning (SLP) method, Plant Floor, Comprehensive Activity relationship chart, Existing Layout, proposed Layout.

1 Introduction

Systematic Layout Planningis a methodical planning process that enables users to recognise, plot, and rank the different tasks, connections, and options associated with a layout project. The technique's three main components are relationships, space, and adjustment. The aim of the work is to improving factory floor layout is to reduce expansion costs by maximising space and flow within the available limits. In order to reduce operating costs and increase process efficiencies, the ideal factory floor layout method entails allotting space and positioning physical assets. At the micro-level layout changes can and

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should be made as and when a need arises. The layout of a factory's equipment, workspaces, and amenities for workers all have an impact on how effectively goods are produced. The smooth and quick transfer of materials from the raw material to the end product can only be guaranteed by a correctly designed plant. It can be characterised as a method of placing equipment, procedures, and plant services inside the factory to produce the desired amount and quality of output at the lowest possible production cost. It requires careful planning of manufacturing facilities to ensure direct workflow.

2 Literature Review

Richard Muther [1] , Lee Hales [2] described about the SLP, it was first being developed in the 1950s, their commitment to solid fundamental concepts, attention on addressing actual issues, and personal encouragement of Richard Muther were all greatly valued and beneficial. In text book Systematic Layout Planning longer than in 50 years, their effective use of SLP on countless projects has led to add helpful updates and explanations to both this version and earlier ones. Carlo et. al. [3] explains, Maximising a manufacturing system's productivity is one of its primary objectives. This depends on a number of variables, including the nature and complexity of the manufactured good, calibre of the raw materials, complexity of the manufacturing process, and configuration of the workstations that make up the manufacturing process. While some of these criteria are fixed and cannot be changed since they are determined by the product, others are variable and can be improved. Subham Barnwal, Prasad Dharamadhikari [4] in their journal describes, To create a new layout using the notion of the Systematic Layout Planning pattern. The proposed paradigm, which is based on the Systematic Layout Planning Pattern Theory (SLP), has been proven successful. The overall distance that the material went decreased, the production rate increased, and the production time decreased. Suhardini, Septiani, and Fauziah [5] describe design simulations and four layout alternatives, each of which is assessed according to two criteria: The processing time by simulation and the cost of material handling as determined by material handling evaluation sheets (MHES). Xiaorong Xu [6] describes the program's entire process is simulated using Flexsim modelling, and the laborious reduction of the entire process is confirmed. Gómez et. al.[7] describes the resolve layout problems in facilities where there are aisles using genetic algorithms.

3 Methodology

3.1 Systematic Layout Planning

The process of arranging a plant's workspace so, that areas with high frequency to be close to one another is known as systematic layout planning. SLP approach used to maximise the current configuration. It is anticipated that the application will create fastest material flow with least amount of material handling and lowest cost. SLP method procedures are represented in Fig.1.
The four phases of SLP are as follows:
Step I: Choose the site which required modifications.
Stage II: Create the general layout of the building.
Stage III: Completely design the layout of the facility.
Stage IV: Getting the design outcomes ready and installed.

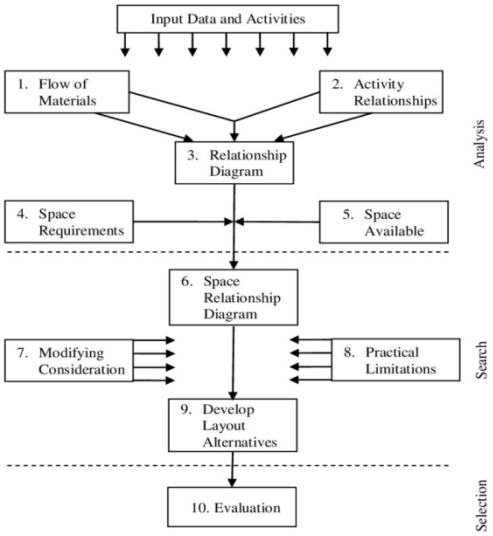

Fig.1. SLP method procedures [7]

3.2 Demand status of gear bush

The work centers are not situated in the Gear Bush manufacturing facility's product flow order. As a result, the current layout has multiple cross movements and extended movements. Additionally, the current layout arrangement has a lot of time-consuming tasks. The status of demand of Gear bush is given in the following Table 1. [5], which gives the complete details of demand for last six months i.e., October 2022 to March 2023.

The gear bush manufacturing company could not meet the demand for production in last six months (as shown in Table 1.). The cause of the problem is the layout which is not in proper alignment the production floor.

Table 1. Demand Status Of Gear Bush

Month	Demand	Capacity	Deviation	Status
October	15,000	12,000	-3,000	Not Fulfilled
November	11,000	12,000	1,000	Fulfilled
December	13,000	12,000	-1,000	Not Fulfilled
January	16,000	12,000	-4,000	Not Fulfilled
February	12,500	12,000	-500	Not Fulfilled
March	11,500	12,000	500	Fulfilled

3.3 Analysis of Present Layout

To enable improvement, a thorough analysis of the current layout is conducted in this part. The initial step that needs to be done as part of the work is gathering departmental details. In order to obtain a fundamental comprehension of the material flow and to detect the primary activities, their successors, and their predecessors, a sequence diagram is also produced.

Table 2. Total Department Areas (sq. ft)

Name of the Department	Total Area	Name of the Department	Total Area
Maintenance Room	3,000	Gauges Inspection (Machining completed parts)	200
Storage Area (Casting parts)	600	Storage Area (Machining completed parts)	600
General Machine Shop	9,200	Final Inspection	2,500
Calibration Room	1,500	Storage Area (FI Completed)	600
CMM	2,000	Pack and Dispatch	3,200
Standard Room	2,000	Rejection Area	600

The Table 2. explain about all the areas of departments, the main changes are need to be done at General Machine Shop because of inefficient utilization of shop floor and long flow of material, Time consuming at setups to new operations every time.

3.4 Analysis of General Machine Shop

In the General machine shop the machines which are used for the production of Gear Bush are LMW, SPINNER 400, DMG MORI. In the company mainly focused on manufacturing of gear bush only. In the below Fig. 2. every possible flow of process is represented, from the understanding of diagram the machine LMW is out of the line, Quality test is important after every step of machining, Gauge inspection at surface table is also required, DMG MORI Machine used for two setups one for Operation-20 and Operation-40, no changes are required in the FI and Dispatch section[6].

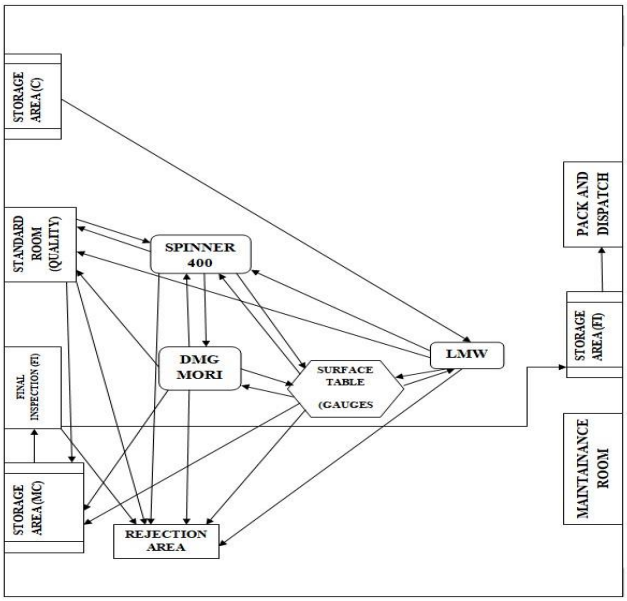

Fig. 2. Present Flow Process and Space Diagram

3.5 Analysis of the Operating Units Relationships

Here, focused primarily on seven operational areas that are directly related to the entire process which are Storage, Machining, Quality, Gauge Inspection, Rejection area, Final Inspection, Pack, and Dispatch from these areas Comprehensive relationship diagram [1] [2] is drawn (as shown in Fig. 2.). The SLP approach was used to arrange the crucial manufacturing sequence in order to continuously optimise the plant's workflow.

The primary issue causes with the current layout are as follows:

- There is a huge distance between the LMW Machine and Quality.
- DMG MORI allows for two operations, but each time a new setup is needed.
- The setup process is primarily to blame for part rejection.
- The storage location for final inspection items is far from final inspection.
- The total manufacturing time is longer per component.

The work unit relationship classification are :
A-Absolutely Important,
E-Very Important,
I-Important,
O-General,
U-Unimportant,
X-Don't Approach.

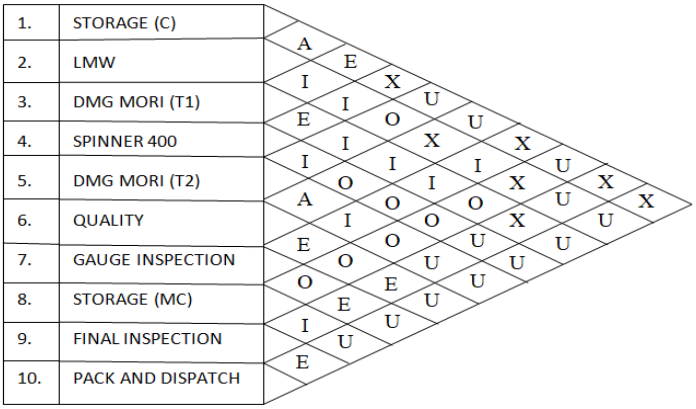

Fig. 3. Comprehensive relationship diagram

The new layout is prepared and implemented (as shown in Fig. 3.). on the shop floor.As the production of the gear bush did not meet the customer requirement a new machine is introduced i.e., TSUGAMI TURNING MACHINE. There is only one crosswalk in the new layout, this cannot be avoided since in the future, other machines occupy the available space [5].

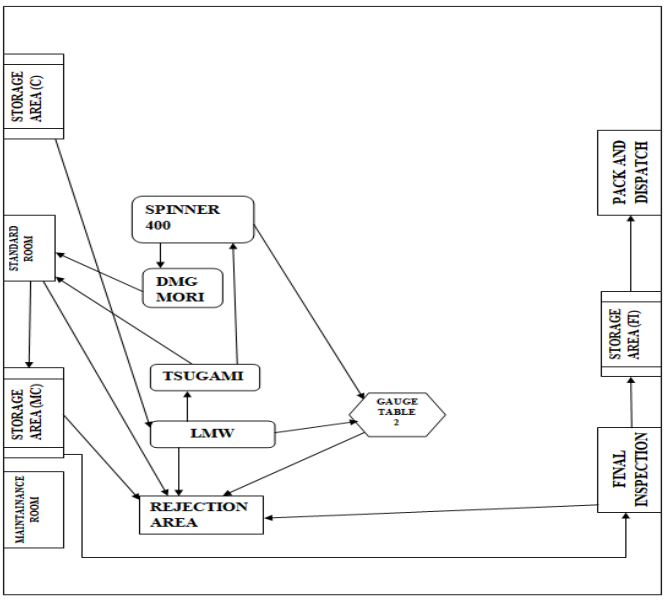

Fig. 4. New Flow Process and Space Diagram

3.6 Proposed Layout Design

Analysis of the plant layout using SLP to examination of manufacturing process revealed that wasted space could be eliminated and long distance decreased. Analysis of the current layout and the altered layout can be done in terms of

- Total Distance (sq. ft).
- Increase in Number of Parts Produced (Total Production).
- Elimination of Ideal Time

- **Total Distance :** The material has travelled a total of 1227 ft. [4] in the current arrangement. However, the altered plan is 799 ft. Table 3. gives the details of distances between departments.

Table 3. Modified Distance Table

S.No	Operation	Distance
1.	Storage Area (Casting)	-
2.	Storage Area (Casting) To LMW Machine	500 (150)
3.	LMW Machine To Gauge Inspection	30
4.	LMW Machine To Quality	200 (40)
5.	LMW Machine To Rejection Area	10
6.	LMW Machine To TSUGAMI Machine	0 (2)
7.	TSUGAMI Machine To Quality	0 (32)
8.	TSUGAMI Machine To Rejection Area	0 (8)
9.	TSUGAMI Machine To Spinner 400	0 (10)
10.	Spinner 400 Machine To Gauge Inspection	10
11.	Spinner 400 Machine To Quality	10 (20)
12.	Spinner 400 Machine To Rejection Area	20
13.	Spinner 400 Machine To DMG MORI	2

14.	DMG MORI Machine To Quality	5
15.	DMG MORI Machine To Rejection Area	10
16.	DMG MORI To Storage Area (M.C)	10
17.	Gauge Inspection To Rejection Area	30
18.	Quality To Rejection Area	100
19.	Storage Area (M.C) To Final Inspection	10 (200)
20.	Final Inspection To Rejection Area	20 (80)
21.	Final Inspection To Storage Area (F.I.)	250 (10)
22.	Final Inspection To Pack and Dispatch	10
	TOTAL DISTANCE	1227 (799)

- **Increase in Number of Parts Produced (Total Production) :** From, Table 4. around 12,000 parts are produced monthly on average. As a result, 400 pieces are created overall in 24 hours. Therefore, a total of 8 hours are needed for the fabrication of 150 pieces. Now that production time [3] has been cut by 4 hours per day, 24,000 more parts may be produced monthly. This will raise output from 12,000 to 24,000 pieces per month, enhancing the company's overall production[10].

Table 4. Total Production Comparison Table

Parts Produced In	Before (Qty)	After (Qty)
Month	12,000	24,000
Day (3 Shifts)	400	800
Shift (8 Hrs)	150	250

- **Elimination of Ideal Time**

A new setup is required at DMG MORI Machine and Setup Approval is obtained from the Quality once LMW Machine operation is complete and the manufactured components are kept in the storage area (Machined parts). The waiting period for the new setup of the machine and Quality Approval is not necessary because the new machine (The Tsugami Turning Machine) has been installed[9]. Total ideal time after new layout is represented in Table 5.

Table 5. Ideal Time Representation Table

Machine Operation	Ideal Time Before	Ideal Time After
LMW Machine	8 Hrs	0
Spinner 300	8 Hrs	0
DMG Mori	8 Hrs	0

3.7 Results And Discussions

The outcomes were examined and contrasted in terms of a number of parameters, which are displayed in Table 6. The total distance, production time, elimination of ideal time were some of the parameters used to compare the original layout and the changed configuration[11]. The total distance, production rate are the primary improvement parameters from the comparison of the present layout and the improved layout.

Table 6. Results of Plant Layout

Conditions	Present Layout	New Layout
Total Distance (Sq. Ft)	1227	799
Number Of Parts Produced(Total Production)	12,000	24,000
Elimination of Ideal Time (Hrs)	8	0

4 Conclusion

Through the usage of a real-world work study, the proposed strategy is demonstrated to be a workable method for resolving production shop floor layout design problems. The manufacturing flow area may be cut from 1227 feet to 799 feet thanks to the more cost-effective alternative arrangement which means that the total distance that materials went decreased by 34%, number of parts produced is doubled and ideal time is zero. The problem with the current plan is relative distance between various departments, which forces them to go a long distance, obstructs the efficient flow of materials, and raises costs[8]. Based on an activity relationship map, it changed the placement of several departments in relation to other departments in suggested plan.

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