SSRG International Journal of Industrial Engineering
ISSN: 2349 – 9362 /doi:10.14445/23499362/IJIE-V7I3P102

Volume 7 Issue 3, 9-24, Sep-Dec 2020

Layout Improvement at a Printing Press

Tushar Kapratwar[1], Siddhi Jadhav[1], Harshvardhan Uttarwar[2], Nirmity Bomidwar[3], Shubham Patil[4]

Students at the Industrial Engineering Department
Vishwakarma Institute of Technology, Pune, India.

Abstract

This paper deals with the development of cellular layout at a printing press that prints customized calendars, magazines, leaflets, brochures, and diaries in medium and large batch sizes. The basic objective for modifying the existing layout into a cellular layout was to eliminate backtracking of material, minimizing work-in-process inventory, minimize transportation and material handling costs, and optimally utilize the available space. A combination of tools and techniques such as Systematic Layout Planning (SLP), Method Study, and Production Flow Analysis & Multicriteria Decision Making tools are employed to effect modifications in the existing layout and evaluate the improvements therein.

Keywords - *SLP, PFA, Method Study, MCDM.*

I. INTRODUCTION

In today's world, companies are competing more on the basis of faster and timely deliveries and mass customization. This necessitates the adoption of cellular layouts. The layout of a company directly affects the productivity and delivery time of the product. Factors such as optimal space utilization, workers' morale, and safety also need to be considered in any layout. In the case problem discussed in this paper, the initial step was to get a grasp of the existing layout and identify the problems encountered. The existing layout was characterized by high WIPs leading to slower deliveries and excessive space utilization and backtracking of material, and excessive movement and travel distance. A set of recording techniques such as P.Q. chart, REL chart, flow process chart, multi-product process chart, and space relationship diagram was used to understand and measure the flow of materials and relationship between various supporting activities (including equipment, storage space, office space, etc.). The production flow technique was used to determine the optimal flow, relocation of equipment, and supporting facilities. A set of alternate layouts were evolved and compared using MCDM techniques to select the best layout. The methodology adopted in the following research is explained in Figure 1.

II. LITERATURE REVIEW

Facilities layout problem is one of the important strategic issues affecting the productivity and efficiency of manufacturing systems. Layouts often fail to consider important factors such as machine dimensions and capacities, production volumes, processing routes, etc. to achieve a good facility layout in a manufacturing environment.

Several quantitative methods and algorithms such as Systematic Layout Planning (SLP), Pairwise Exchange Method (PEM), Graph-Based Theory (GBT), Dimensionless Block Diagram (DBD), Total Closeness Rating (TCR), Analytic Hierarchy Process (AHP), Data Envelopment Analysis (DEA), Simulation, etc. have been proposed by facility planners for obtaining efficient layouts.

U. Tarigan and M. B. Ambarita used SLP as a strategy used to set the plant layout in which machines with high recurrence are put near to one another. This method helps in enhancing the current plant layout. Method to re-layout the generation floor comprises three stages, for example, dissecting the current format, structure the plant design dependent on the SLP, and the assessment and choice of alternative designs utilizing the simulation Pro model. [6]

Y. Ojaghi et al. [16], in addition to SLP, used a Graph-based theory (GBT) technique that uses REL chart to find the most important adjacency between departments and determine the priority of selecting departments. Alternative layouts developed are compared using an Efficiency Rate (E.R.) value. The selected layout was further improved using the PEM program in MATLAB software that got an even higher efficiency rate value. A. Roberts presented an ideal integrated layout design model that integrates all design factors such as department formation, material handling system selection, production and inventory control, etc. with flow-based department formation. Appropriate solution procedures are developed to generate efficient manufacturing system design [4]. F. Sadeghpour, O. Moselhi, and S. Alkass used the 3 main attributes viz., site objects, construction objects, and constraint objects for planning layout of the construction site. A CAD-based model identifies important attributes of layout planning and assists site planners and superintendents in performing their task efficiently. [2] K. Schlee, J. Ristow, S. C. M. Blvd, C. Hubert, and P. O. Box proposed that simulation is the only methodology robust enough to systematically examine the role and impact of product complexity and other key variables on factory performance. It helps in dealing with problems exhibiting uncertainties, justify production strategies and improve operational layout parameters [11]. J. Guang Yu proposed that using a CAD simulator helps in generating a layout very precise in dimensional accuracy using actual units from the architect's point of view. Some of these methods can be used to generate a layout from scratch (i.e., PLANET, CORELAP, ALDEP, FACTORY Plan) while others can be used to improve an existing layout (i.e., CRAFT, COFAD, FACTORY Flow) [8].

T. Yang and C. Kuo used an analytic hierarchy process (AHP) and data envelopment analysis (DEA) approach to solve a plant layout design problem. Qualitative performance measures were weighted by AHP and DEA to solve the multiple- objective layout problem. AHP helps in assigning the weights to factors, expressing the relative importance of those layout alternatives for each criterion. DEA is used to derived results from solved AHP. A computer-aided, layout-planning tool can be adapted to generate layout alternatives as well as to compute quantitative DMU (decision-making units) outputs [5].

M. Bazargan Lari used goal programming and simulated annealing to determine shop floor boundaries, closeness relation between machines, traveling cost, and machine orientation in which the targets to be achieved are set, as provided by the decision-maker, along with the initial solution and steps to subsequently improve the quality of the solution [7]. D. I. Patsiatzis and L. G. Papageorgiou formulated a mathematical program that calculated the number of floors, land area, optimal equipment-floor allocation, and equipment location (i.e., coordinates and orientation) simultaneously so as to minimize the total plant layout cost [13].

K. Ueda et al. used a concept of Biological Manufacturing Systems, which included ideas such as self-organization that generate facility layout plans autonomously according to the material flow, which emerges from the local interactions among machines and AGVs. Machines were arranged in concentric circles. The placement of machines was based on the frequency of use and processing time to reduce material handling [10]. S. Bock and K. Hoberg used a grid-based layout structure that defines the existing layout as a grid of uniform squares that map every machine and transportation path as a set of adjacent unit-elements. The approach supports a detailed mapping of irregular but fixed machine shapes. [9]

S. K. Deb and B. Bhattacharyya designed and compared two improved layouts using the multifactor normalized method and the fuzzy decision support system. Different values associated with different linguistic variables are used in the formulation of a proposed layout that leads to lesser 'dead space' and 'minimum required area of layout' than the normalized methods of the layout. [12]

III. METHODOLOGY

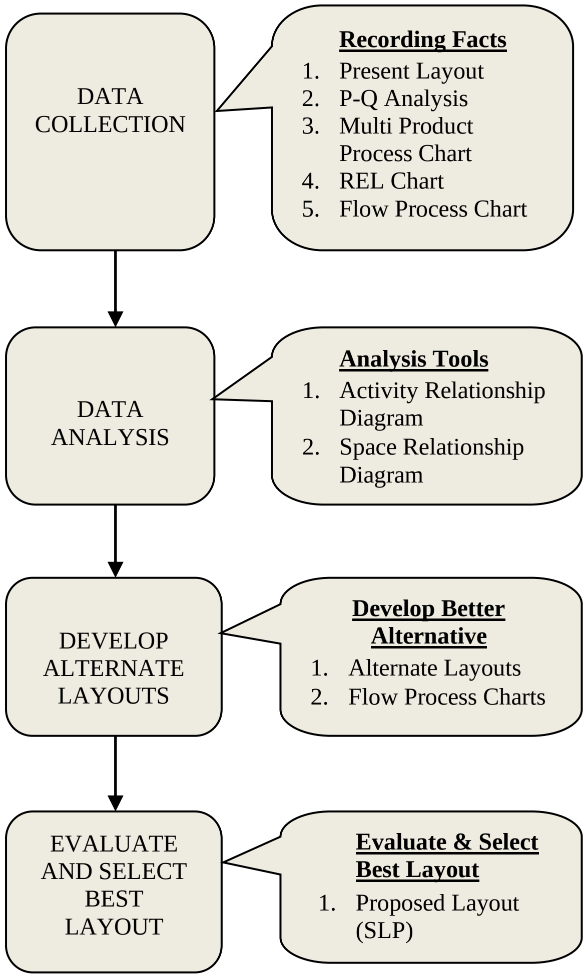


Figure 1: - Methodology adopted

A. Present layout

Figure 2 shows the present state of the layout in the printing press. Figure 3 is a guide for actual machine dimensions and the color code to represent the respective flow of each product. Discussions with employees led to the identification of certain problems. For products like brochures and magazines, operators traveled to a different unit for some processes, which led to increased distance. Also, the finished products were taken to another unit for packaging and shipment. As a result, the 'distance traveled' and the 'time required' was considerably more. Hence, a systematic layout planning tool is used for improving the existing layout.

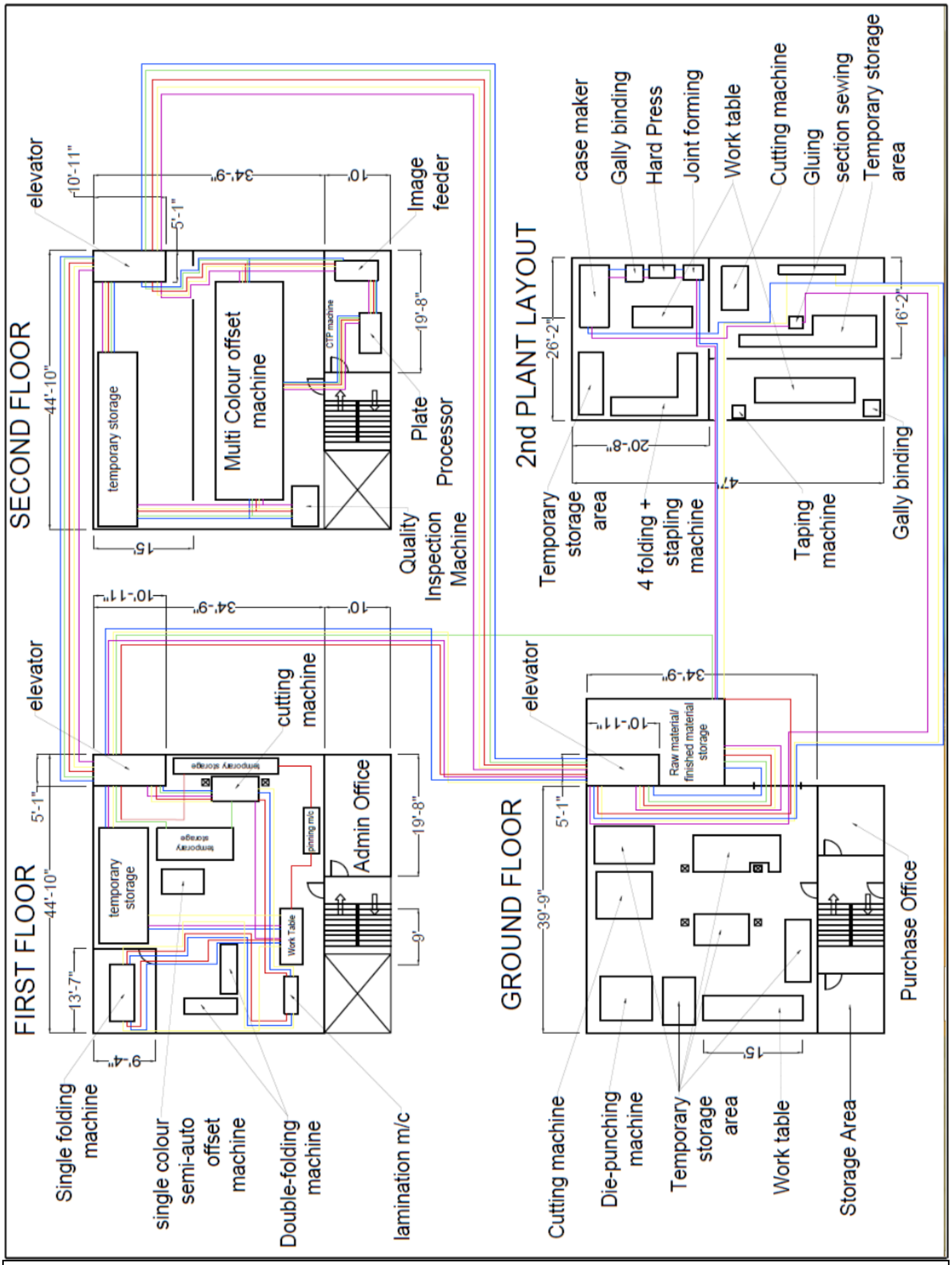


Figure 2: - Present Layout

Machine's Guide

Machine Name	Location	Dimensions (l' x b')
Image feeder (CTP)	Second floor	6'-5" x 3'-3"
Plate processor (CTP)	Second floor	6'-5" x 3'-3"
Multi Colour Offset machine	Second floor	35' x 10'-3"
Inspection machine	Second floor	6'-5" x 4'
Single folding machine	First floor	9'-3" x 3'-8"
Double folding machine	First floor	8' x 2'-6"
Double folding machine	First floor	8' x 2'-6"
Single colour semi-auto offset	First floor	6'-4" x 4'
Cutting machine	First floor	7' x 4'
Lamination	First floor	6' x 2'
Pinning	First floor	7'-6" x 2'-4"
Die-punching	Ground floor	7'-10" x 7'-2"
Cutting machine	Ground floor	8'-5" x 7'7"
Case Maker	2nd Plant	10' x 4'-4"
Gally binding	2nd Plant	2'-7" x 2'-7"
Hard press	2nd Plant	3'-10" x 2'
Joint forming	2nd Plant	2'-11" x 2'-3"
Cutting machine	2nd Plant	7' x 4'
Gally binding	2nd Plant	2'-7" x 2'-7"
Gluing	2nd Plant	10' x 1'-6"
4 folding + stapling	2nd Plant	13' x 3'
Section Sewing	2nd Plant	2' x 2'

Legend

Product name	Colour
Brochures	Blue
Magazines	Red
Diaries	Purple
Leaflet	Green
Calender	Yellow

Figure 3: Machine dimensions and product color on the layout

B. Procedure for Systematic Layout Planning.

Systematic Layout Planning is a tool used to improve the existing layout, and maximize the direct flow of material, reduce unnecessary transport while taking into consideration practical limitations to evolve improved layouts. Figure 4 helps us understand different steps and stages in SLP along with the sequence of implementation.

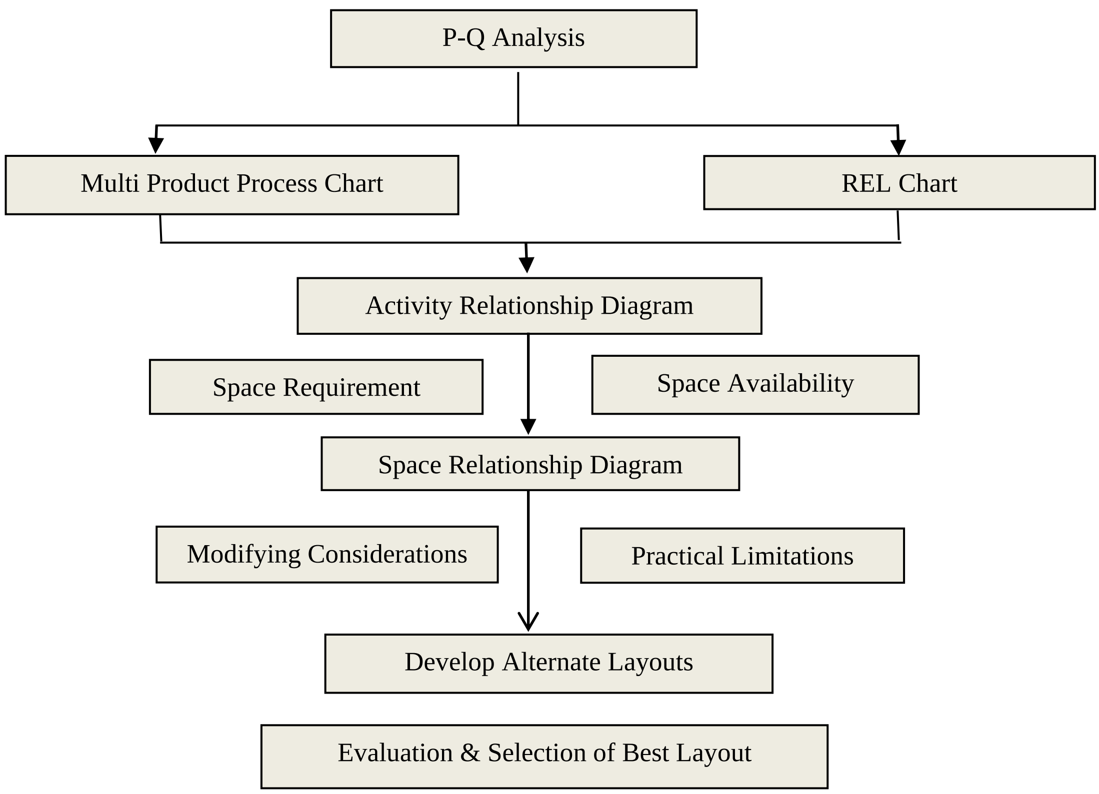
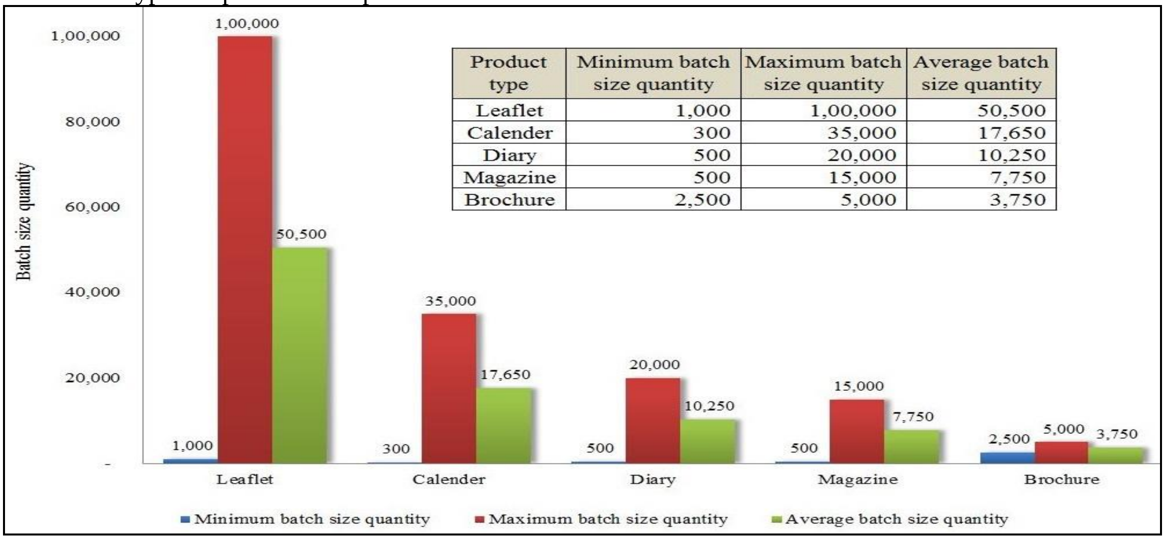


Figure 4: - Steps of Systematic Layout Planning

a) P.Q. Chart

The company produces a variety of customized products like leaflets, calendars, diaries, magazines, boxes, brochures, and paper bags in pre-determined batch sizes. Fig. 5 shows the batch size and volumes produced. P.Q. chart shows that 8 types of products are printed in different batch sizes ranging from 100,000 units to 300 units. The batch size of the leaflet is observed to be the highest, and the average batch size of paper bags is lowest. The volume of all the different products printed is spread over a wide range, thus suggesting a design of the cellular layout.



Product type	Minimum batch size quantity	Maximum batch size quantity	Average batch size quantity
Leaflet	1,000	1,00,000	50,500
Calender	300	35,000	17,650
Diary	500	20,000	10,250
Magazine	500	15,000	7,750
Brochure	2,500	5,000	3,750

Figure 5: - Product Variety & Volume Product-Quantity Chart

b) Multi-Product Process Chart

Figure 6 shows a multi-product process chart that depicts the flow of five main categories of products printed in the company. Although several varieties exist within the five main categories, the process flow usually remains the same. The process flow and sequence are similar for the initial few stages. Subsequently, the flow varies as per the specific printing and binding requirements for each product category. A few machines such as image feeder, CTP, four-color printing machine, etc. cater to all product categories and hence, are optimally utilized. Other machines or types of equipment are used for a few product categories only. For example, the gluing process is only used for boxes. The chart gives a bird's eye view of the whole process for all product categories and helps in determining their optimum location.

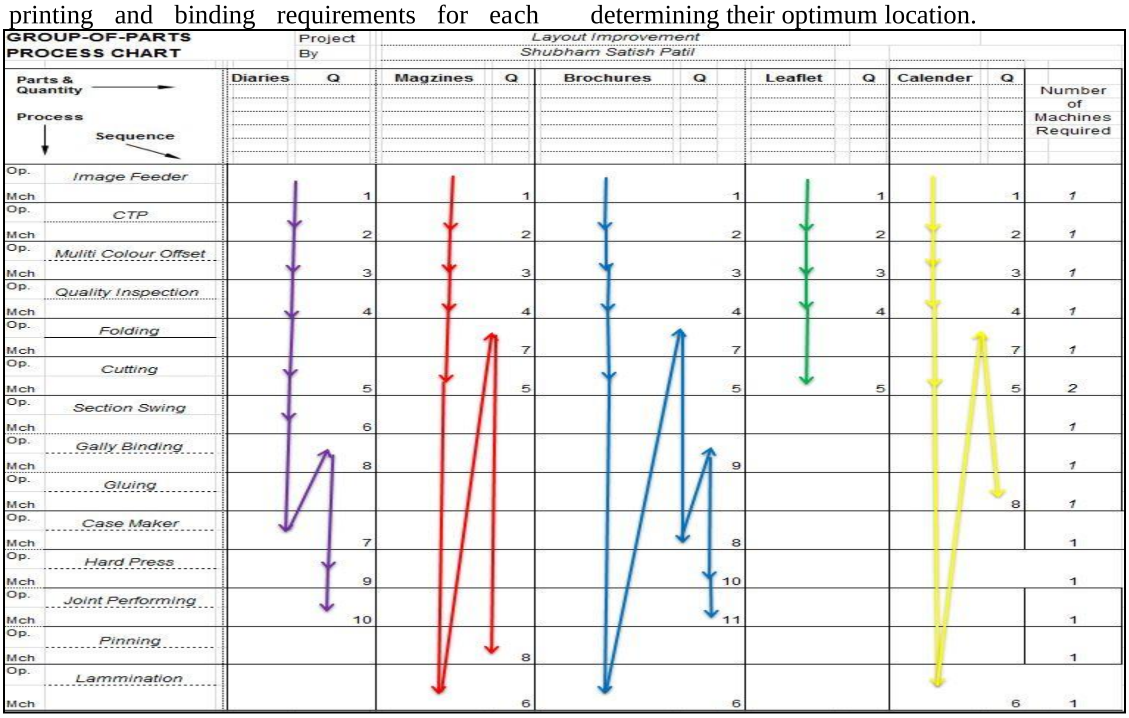


Figure 6: - Multi-product process chart

c) REL Chart

Figure 7 shows the relationship between all major printing processes and supporting services in the form of a closeness rating. Closeness ratings for sixteen activities are given along with reasons justifying them. Six closeness ratings viz., A, E, I, O, U, and X are used for determining the relative importance of closeness between two activities. 'A' rating is the highest and U the lowest so far as the close relationship between two activities is concerned. 'X' rating signifies proximity between two activities is undesirable, and hence these activities should be located as far as possible. The ratings were obtained after consultation with the employees in the printing press and were based on their prior experiences and expertise. The ratings were primarily based on the volume of flow of materials for printing processes (production processes) and the flow of information and people for the supporting services (service departments). Inferences derived from the multi-product process chart were also factored in to rate the printing process activities.

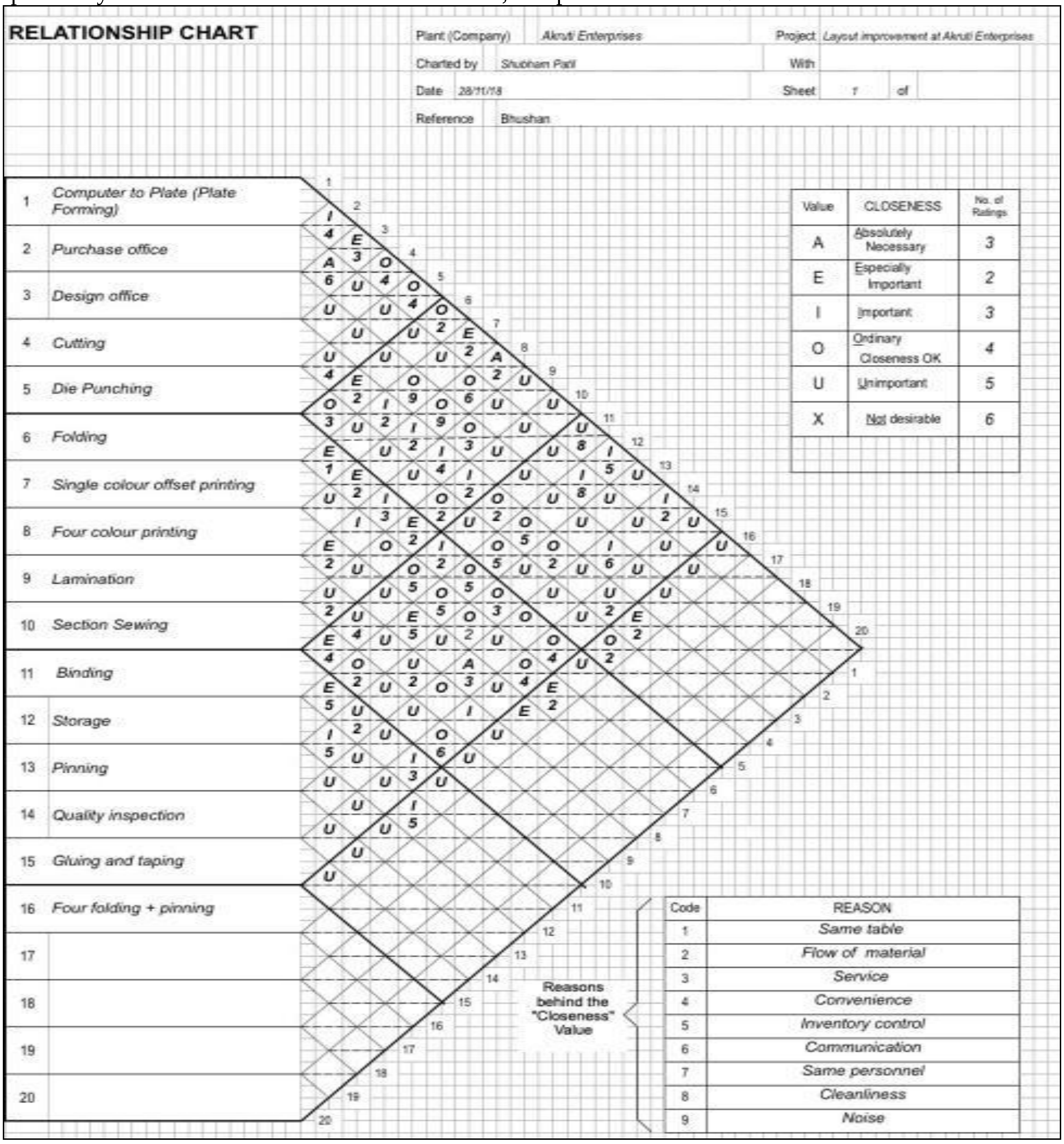


Figure 7: Relationship Chart (REL Chart)

d) Activity Relationship Diagram

Using the relations' closeness value between the machines, refer to the REL chart (fig. 7), the activity relationship diagram is designed (fig. 8). This diagram helps in the spatial organization of the machines while constructing the Alternative layouts. When organizing the position of machines, there could be some machines that may not be required for the production of each type of product. For example, while manufacturing magazines, it's not necessary that every time the pinning operation would be required. This is because, as mentioned above, the company makes customized products for their customers. So, it depends on the type of magazine the customer wants, and accordingly, the process to manufacture it also varies slightly. Therefore, some machines which are not required every time to manufacture the products are given a smaller closeness value. Considering such practical constraints after consulting with the managers at the factory, the closeness values are decided for the relation between two machines.

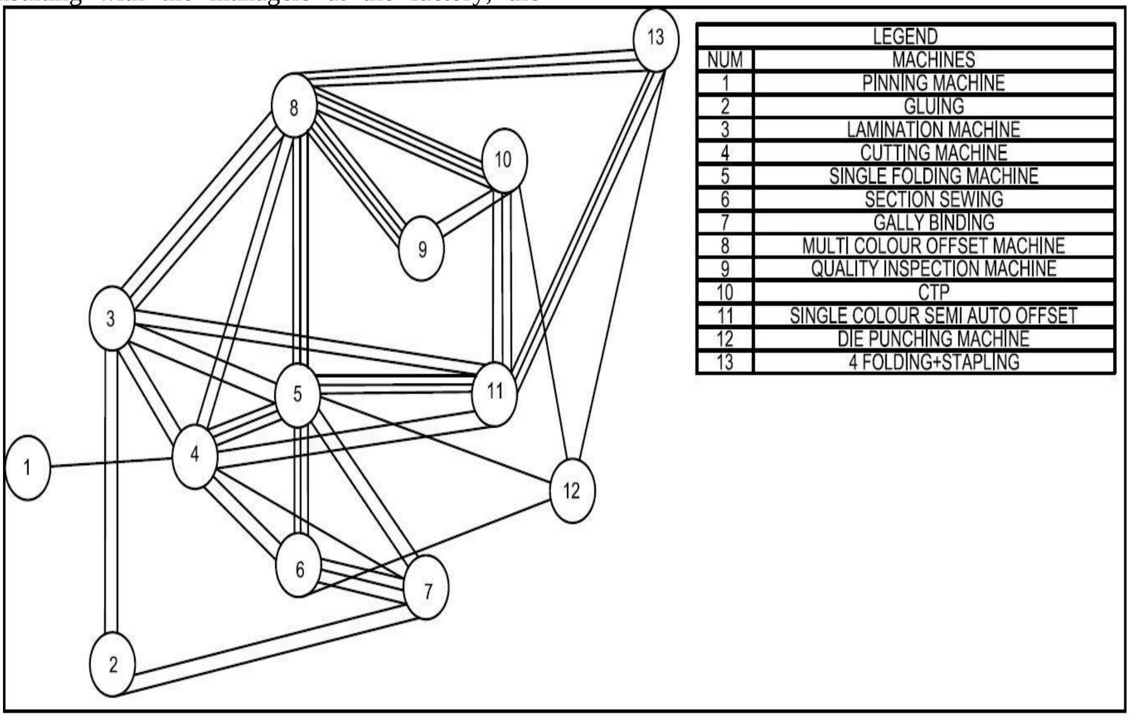


Figure 8: - Activity Relationship Diagram

e) Space Relationship Diagram

Figure 9 is the space relationship diagram, which was constructed by using closeness ratings of the REL chart and by scaling actual dimensions of various departments. The multi-color offset machine needs maximum space, and the section sewing machine requires the least space. The lines between these machines show closeness priority. For example, it is absolutely necessary that the quality inspection machine, along with the computer-to-plate machine, should be close to a multi-color offset machine.

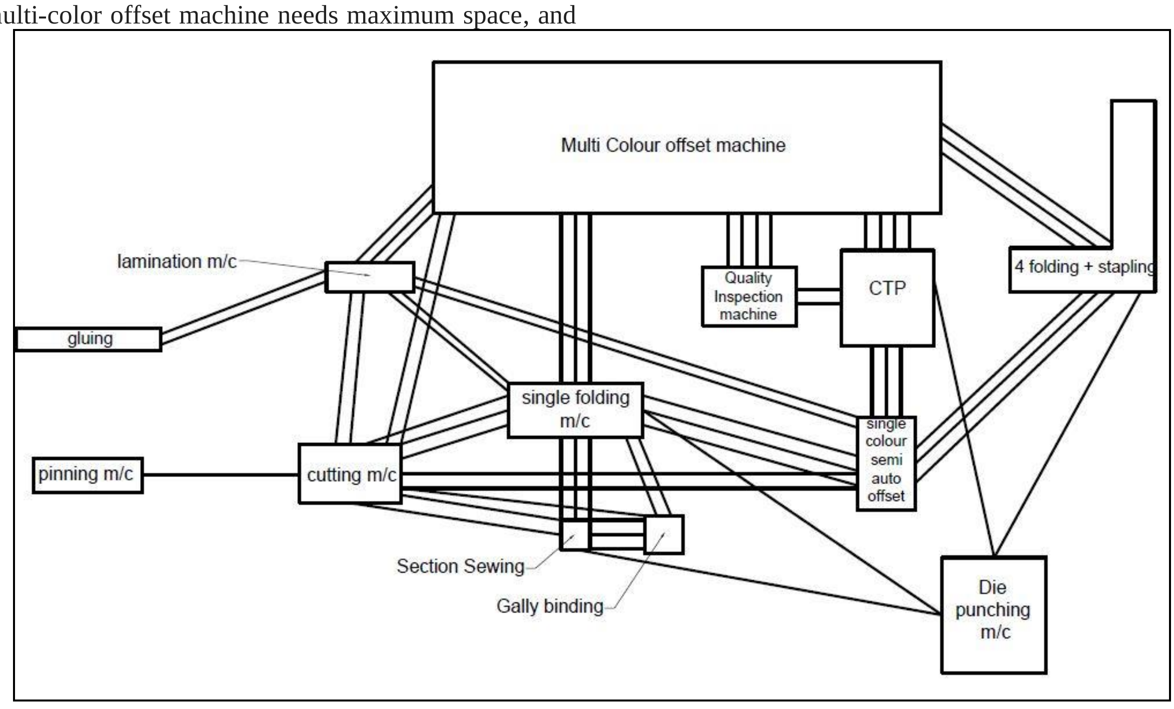


Figure 9: - Space Relationship Diagram

f) Space Availability and Space Requirement

Figure 10 shows the space available and required for the machines. This includes the space needed for the equipment, machine travel, machine maintenance, and other plant services. In order to overcome the constraint of huge travel distance between two plants, machines in the second plant that are common for all the products are moved to the first plant. While moving the machines, the above-mentioned spaces are needed to be considered.

This tool helps where any activity or area is so diverse and complicated that detailed calculations are not warranted, or the product or quantity information is too general or too indefinite to justify using the calculation method.

SPACE REQUIREMENTS -- CONVERTING				
Plant	xyz Printing Press	Project	*Layout Improvement in a Printing Press*	
By	*Tushar Kapratwar*	With	*Siddhi Jadhav*	
	Activity-- Area or Dept.	Area Now Occupied	+ or - Adjstmt.	Should Have Now
	Unit →	sq. ft.	sq. ft.	sq. ft.
1.	*Computer to Plate (CTP)*	197	0	197
2	*Multi colour offset printing m/c*	885	0	885
3	*Cutting m/c*	130	-45	85
4	*Die-Punching m/c*	164	16	180
5	*Single Folding m/c*	125	0	125
6	*Single colour offset printing m/c*	125	0	125
7	*Lamination m/c*	70	0	70
8	*Section Sewing*	46	-11	35
9	*Gally Binding*	27	5	33
10	*Pinning m/c*	18	0	18
11	*Quality Inspetion*	42	0	42
12	*Gluing m/c*	90	-55	35
13	*Four folding + pinning machine*	236	0	236
	TOTAL	2,155		2,066

Figure 10: - Space Available and Required

g) Proposed Layouts

On studying and evaluating the current layout, faults were seen and identified. The flow of different products can be traced using colored lines (brochure -blue, magazine-red, leaflet-green, calendar - yellow, diary-purple), as shown in Figure 3.

Alternate layouts (A.L.) were constructed with the objective of minimizing product travel distance and hence reducing the work in progress due to excess material handling. Various practical constraints are considered as suggested by the people working in the factory while designing the A.L.s. The major difference between AL-1 and AL -2 is that, in the first layout, the need to transport the material to 2nd plant layout has been eliminated. The machines placed in 2nd plant layout are the ones that are not required frequently for the manufacturing purpose of the mentioned products. This resulted in a large saving of distance traveled between two plants.

In the second layout, all the service-related offices on the ground floor are moved to the third floor, keeping the safety and avoiding any damage to the structure of the building. Refer to figure 11 and figure 12.

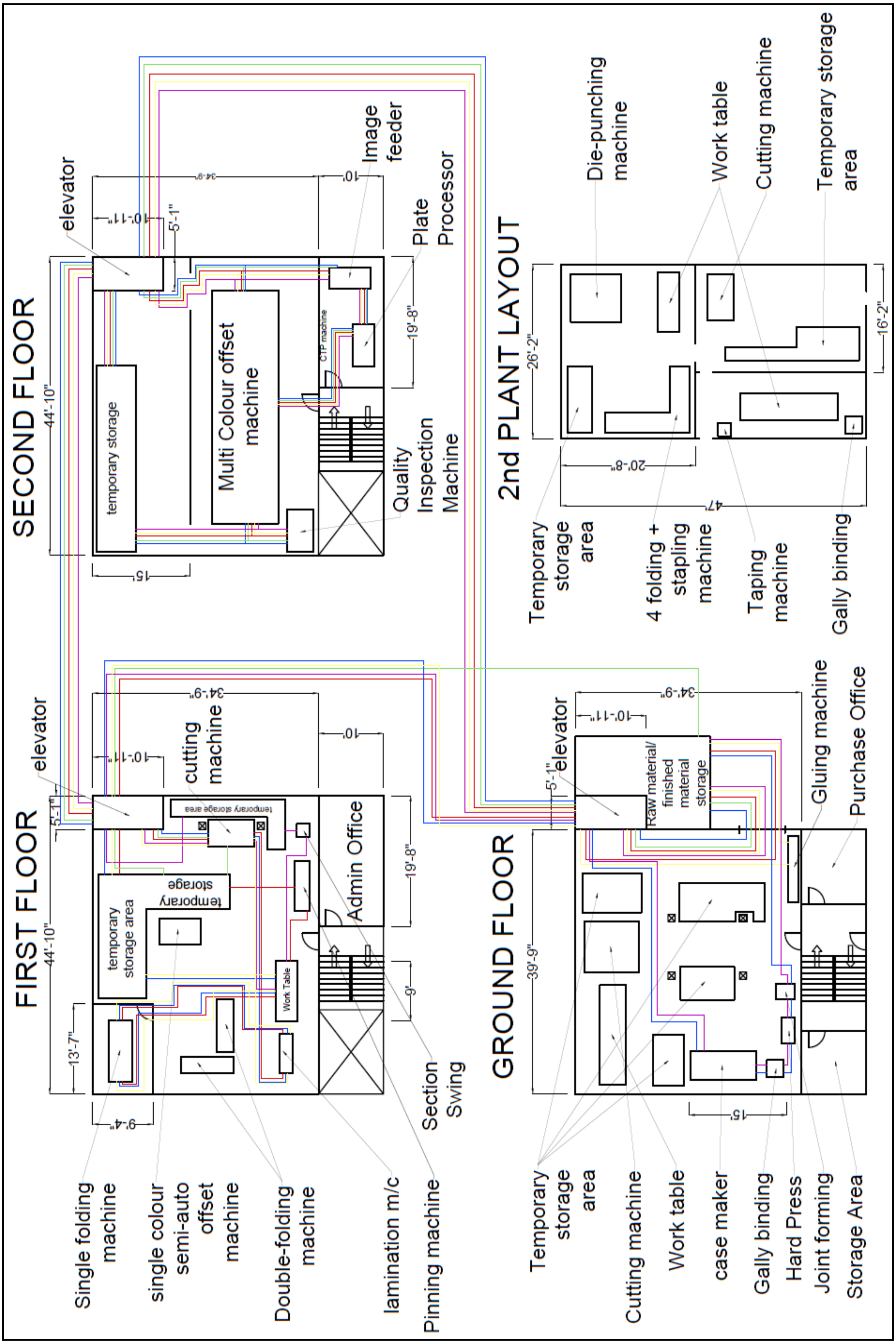


Figure 11: - Alternative Layout 1

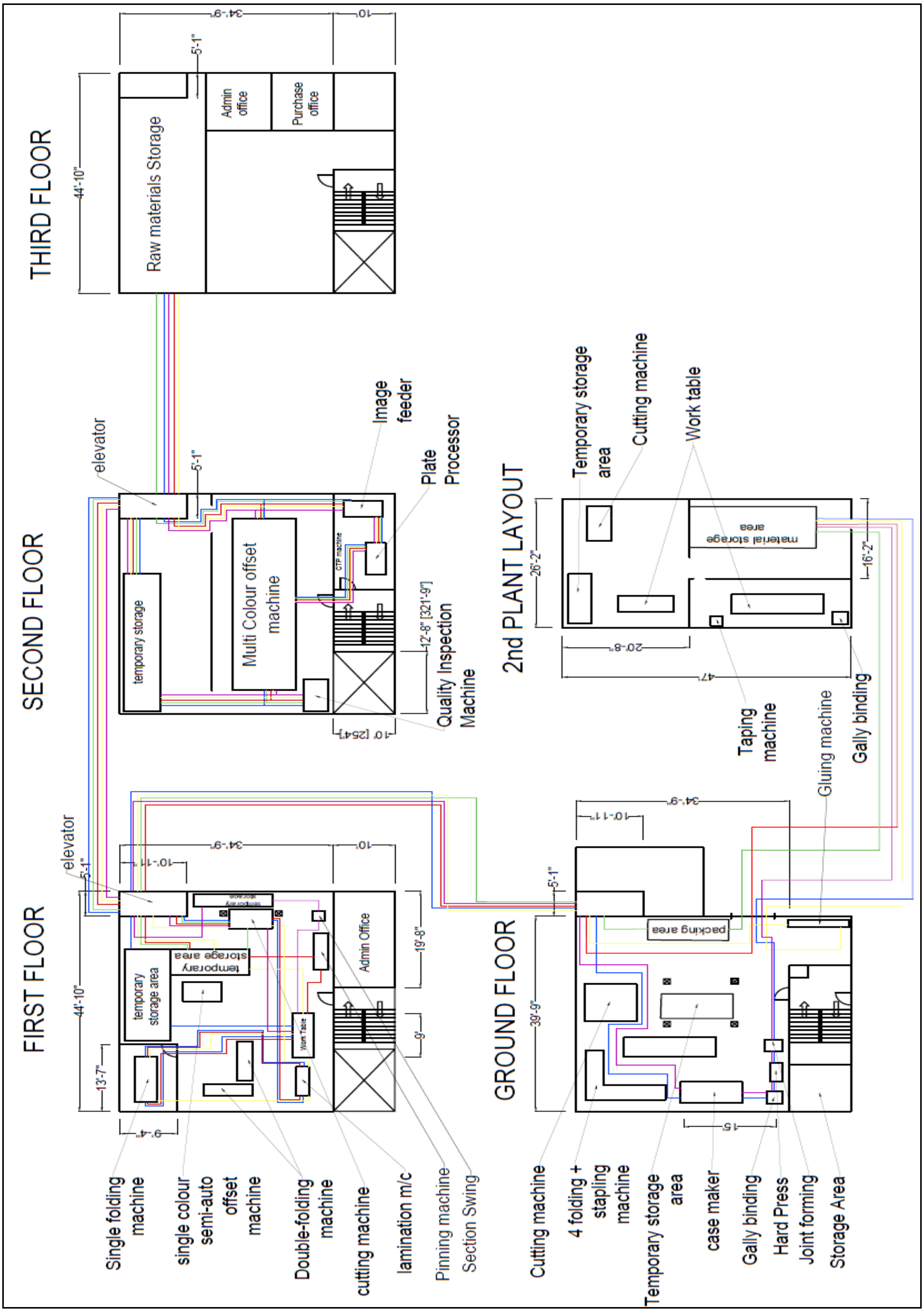


Figure 12: - Alternative Layout 2

h) Flow Process Charts

Initially, the present state's flow process charts were made to record the details of activities carried out for each product. These charts contain all the detailed activities like the number of operations, transport, delays, inspections carried out, and storage activities for the whole product right from its raw material state to its finished goods state. Table 1 shows an example of a summary table of the flow process chart of Diaries in AL-1. Similarly, there are five flow process charts for five products for present layout, alternative layout-1, and alternative layout-2 that make a total of 15 flow process charts used to show the present and proposed states.

Summary	Present No.	Proposed No.	Difference No.
Operations	13	13	0
Handlings	18	19	1
Transportations	16	15	1
Inspections	1	1	0
Delays	5	5	0
Storages	2	2	0
Distance Traveled	435 ft	225 ft	200

Charted by	Nirmity	Date	15/11/2018	Sheet of		Diaries	
☐ Man or	☑ Material						
Chart begins	Take the raw material from storage to elevator						
Chart ends	Storage/Dispatch						

Details of Method: ☑ Present ☐ Proposed

No.	Details of Method	Operation	Handling	Transport	Inspection	Delay	Storage	Distance in ft	Time in sec	Quantity	What?	Where?	When?	Who?	How?	Notes	Eliminat	Combin	Sequen	Place	Person Improve
1.	Take the raw material from storage to elevator		●					36	50	10,000						RM is stored in outer storage					
2.	*Wait for elevator*					●			4	10,000											
3.	*Get into elevator with hand truck*			●				2	5	10,000											
4.	*Go from ground floor to 2nd floor*			●					8	10,000											
5.	*Take the hand truck to offset printing (raw material storage area)*			●				12	20	10,000											
6.	*Unload*		●						30	10,000											
7.	*Repeat the process as required*																				
9.	*Take plate from nearby storage and load it to plate forming m/c*		●					2	15	1											
10.	*Give instructions to plate forming m/c*	●						1	30	1											
11.	*operation*	●							20	1											
12.	*Unload the plate*		●						2	1											
13.	*wait*					●			10	1											
14.	*Load the plate to image feeder machine*		●					2	2	1											
15.	*operation*	●							30	1											
16.	*Unload the plate*		●						2	1											
17.	*Repeat the process 4 times (for 1 page)*							20	348	4											
19.	*Take the plate to offset printing*		●					5	5	4											
20.	*Punch the plates*	●							20	4											
21.	*Insert the plates in offset printing machine*	●						3	180	4											
22	*Take the raw material from storage to offset printing machine*			●				2	60	1000											
23	*Loading papers to off-set printing machine*		●					1	240	1000											
24	*Load the sample papers*		●						15	30											
25	*Passing the sample papers*	●							10	30											
26	*Quality check*				●			2	100	30											
27	*Printing 1000 papers*	●							300	1000											
28	*Unloading papers*		●						30	1000											
29	*Taking the hand truck to storage*			●				4	60	1000											
30	*Waiting for ink to dry*						●		1800	10000											
31	*Repeat the above process 10 times*							90	8150	10000											
32	*Load the papers to hand truck*		●					1	20	10000											
33	*Go to elevator*			●				4	15	10000											
34	*Wait for elevator*					●			4	10000											
35	*Get into elevator with hand truck*			●				2	4	10000											
36	*Going to 1st floor*			●					4	10000											
37	*Take the hand truck to cutting machine*			●				5	10	10000											
38	*Loading the papers*		●					1	45	500											
39	*operation*	●							56	500											

Table 1-a: - Flow Process chart (Existing Layout)

39	operation	●	⬡	⇨	□	D	▽		56	500	
40	Unloading papers	○	⬢	⇨	□	D	▽	1	40	500	
41	Repeat the above process 20 times							40	2820	10000	
42	Arrange the papers on table	○	⬢	⇨	□	D	▽		**300**	100	arranging stack of 100 pages at a time
43	Operation (1 booklet folding)	●	⬡	⇨	□	D	▽		**20000**	1000	
44	load the booklets on hand truck	○	⬢	⇨	□	D	▽		**60**	1000	
45	Go to elevator	○	⬡	➡	□	D	▽	**10**	**20**	1000	
46	Wait for elevator	○	⬡	⇨	□	◗	▽		**4**	1000	
47	Get into elevator with hand truck	○	⬡	➡	□	D	▽	**2**	**4**	1000	
48	Going to ground floor	○	⬡	➡	□	D	▽		**4**	1000	
49	Take the hand truck to section 2	○	⬡	➡	□	D	▽	**110**	**470**	1000	
50	Take it to sewing machine	○	⬡	➡	□	D	▽	**10**	**30**		
51	loading booklet	○	⬢	⇨	□	D	▽		4	1	
52	Operation (for 1 booklet)	●	⬡	⇨	□	D	▽		4	1	
53	Unloading	○	⬢	⇨	□	D	▽		4	1	
54	Repeat the above process 1000 times								12000	1000	
55	take the hand truck to gally binding machine	○	⬡	➡	□	D	▽	10	30	1000	
56	Process of gally binding + hard press + joint formin	●	⬡	⇨	□	D	▽	**4**	**200000**	1000	
57	Taking it on hand truck	○	⬢	⇨	□	D	▽		**30**	1000	
58	Carrying this finished products to the storage section	○	⬡	➡	□	D	▽	**120**	**400**	1000	
59	Stacking (set of 100)	●	⬡	⇨	□	D	▽	**2**	**300**	1000	
60	Packing	●	⬡	⇨	□	D	▽		**300**	1000	
61	Storage/dispatch	○	⬡	⇨	□	D	▼				
	Total							**435**	**247190**		

Table 1-b: - Flow Process chart (Existing Layout)

Summary	Present No.	Proposed No.	Difference No.
Operations	13	13	0
Handlings	18	19	1
Transportations	16	15	1
Inspections	1	1	0
Delays	5	5	0
Storages	2	2	0
Distance Traveled	425 ft	225 ft	200 ft

Charted by	Nirmity
Date	15/11/2018
Sheet of	Diaries
☐ Man or ☑ Material	
Chart begins	*Take the raw material from storage to elevator*
Chart ends	*Storage/Dispatch*

Details of Method: ☐ Present ☑ Proposed

No.	Details of Method	Operation	Handling	Transport	Inspection	Delay	Storage	Distance in feet	Time in sec	Quantity	Analysis (Why? What? Where? When? Who? How?)	Notes	Action (Change: Eliminate, Combine, Sequence, Place, Person, Improve)
1.	Take the raw material from storage to elevator		●					36	50	10,000		*RM is taken from outside storage area*	
2.	*Wait for elevator*					●			4	10,000			
3.	*Get into elevator with hand truck*			●				2	*5*	10,000			
4.	*Go from ground floor to 2nd floor*			●					*8*	10,000			
5.	*Take the hand truck to offset printing (raw material storage area)*			●				12	*20*	10,000			
6.	*Unload*		●						30	10,000			
7.	*Repeat the process as required*												
9.	*Take plate from nearby storage and load it to plate forming m/c*		●					2	*15*	1			
10.	*Give instructions to plate forming m/c*	●						1	*30*	1			
11.	*operation*	●							*20*	1			
12.	*Unload the plate*		●						*2*	1			
13.	*wait*					●			*10*	1			
14.	*Load the plate to image feeder machine*		●					2	*2*	1			
15.	*operation*	●							*30*	1			
16.	*Unload the plate*		●						*2*	1			
17.	*Repeat the process 4 times (for 1 page)*							20	*348*	4			
19.	*Take the plate to offset printing*		●					5	*5*	4			
20.	*Punch the plates*	●							*20*	4			
21.	*Insert the plates in offset printing machine*	●						3	180	4			
22	*Take the raw material from storage to offset printing machine*			●				2	60	1000			
23	*Loading papers to off-set printing machine*		●					1	*240*	1000			
24	*Load the sample papers*		●						*15*	30			
25	*Passing the sample papers*	●							*10*	30			
26	*Quality check*				●			2	*100*	30			
27	*Printing 1000 papers*	●							*300*	1000			
28	*Unloading papers*		●						*30*	1000			
29	*Taking the hand truck to storage*			●				4	60	1000			
30	*Waiting for ink to dry*					●	●		*1800*	10000			
31	*Repeat the above process 10 times*							90	*8150*	10000			
32	*Load the papers to hand truck*		●					1	*20*	10000			

Table 2-a: - Flow Process chart (Proposed Alternative Layout-1)

33	Go to elevator	○	⬡	➡	□	D	▽	4	15	10000	
34	Wait for elevator	○	⬡	⇨	□	◗	▽		4	10000	
35	Get into elevator with hand truck	○	⬡	➡	□	D	▽	2	4	10000	
36	Going to 1st floor	○	⬡	➡	□	D	▽		4	10000	
37	Take the hand truck to cutting machine	○	⬡	➡	□	D	▽	5	10	10000	
38	Loading the papers	○	◐	⇨	□	D	▽	1	45	500	
39	operation	●	⬡	⇨	□	D	▽		56	500	
40	Unloading papers	○	◐	⇨	□	D	▽	1	40	500	
41	Repeat the above process 20 times							40	2820	10000	
42	Arrange the papers on table	○	◐	⇨	□	D	▽		300	100	arranging stack of 100 pages at a time
43	Operation (1 booklet folding)	●	⬡	⇨	□	D	▽		20000	1000	
44	load the booklets on hand truck	○	◐	⇨	□	D	▽	1	60	1000	
45	Take it to sewing machine	○	⬡	➡	□	D	▽	8	10	1000	
46	loading booklet	○	◐	⇨	□	D	▽		4	1	
47	Operation (for 1 booklet)	●	⬡	⇨	□	D	▽		4	1	
48	Unloading	○	◐	⇨	□	D	▽		4	1	
49	Repeat the above process 1000 times(for 1000 diaries)								12000	1000	
50	Take the booklet on hand truck	○	◐	⇨	□	D	▽		120	1000	
51	Go to elevator	○	⬡	➡	□	D	▽	11	20	1000	
52	Wait for elevator	○	⬡	⇨	□	◗	▽		4	1000	
53	Get into elevator with hand truck	○	⬡	➡	□	D	▽	2	4	1000	
54	Going to ground floor	○	⬡	➡	□	D	▽		4	1000	
55	Take the hand truck to gally binding machine	○	⬡	➡	□	D	▽	24	30	1000	
56	Process of gally binding + hard press + joint forming	●	⬡	⇨	□	D	▽	4	200000	1000	
57	Taking it on hand truck	○	◐	⇨	□	D	▽		30	1000	
58	Carrying this finished products to the storage section	○	⬡	➡	□	D	▽	6	400	1000	
59	Stacking (set of 100)	●	⬡	⇨	□	D	▽	2	300	1000	
60	Packing	●	⬡	⇨	□	D	▽		300	1000	
61	Storage/dispatch	○	⬡	⇨	□	D	▼				
	Total							225	246820		

Table 2-b: - Flow Process chart (Proposed Alternative Layout-1)

IV. RESULTS AND DISCUSSION

Figure 13 shows the distance saved in both layouts of each product. Combined savings of 479 feet are observed on an average in Alternate layout - 1, whereas savings of 590 feet are observed when we implement the alternate layout-2. Out of five products, the calendar got the maximum savings of 50% and 53% in alternative layouts 1 and 2, respectively. Furthermore, alternative layout 1 showed an average savings of 22.5% savings for every product and similarly 31.6% in alternative layout-2.

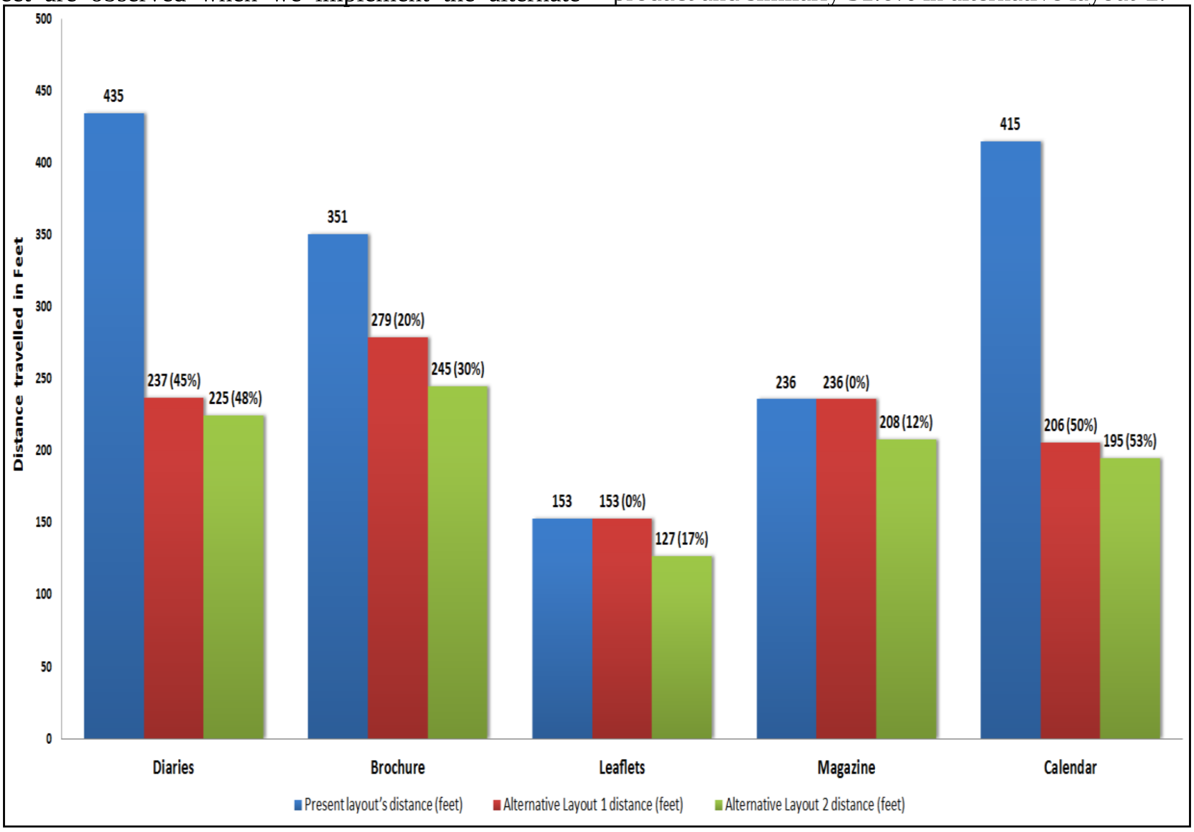


Figure 13: - Layout Comparison (Distance Travelled)

V. CONCLUSION

A well-designed layout results in improved efficiency, lesser material handling and reduction in delivery time of products manufactured. Work in progress was reduced considerably using various tools of layout planning. Layout was improved and feet traveled were reduced, resulting in higher productivity. Materials were carried for a longer distance which meant a waste of time and energy, resulting in high cost. All these tools and techniques directly and indirectly help in reducing the cost of production and distance travelled.

VI. ACKNOWLEDGMENT

This paper and the work behind it would not have been possible without the support of our guide Dr Prof Rajesh Dhake. His knowledge and encouragement have kept us inspired and helped us achieve our goal. We thank him for his constant guidance.

REFERENCES

[1] F. Sadeghpour, O. Moselhi, and S. Alkass, *"A CAD-based model for site planning,"* Autom. Constr., vol.13, no. 6, pp. 701–715, 2004.

[2] H. Schmidt-Traub, M. Köster, T. Holtkötter, and N.Nipper, "*Conceptual plant layout*," Comput. Chem. Eng., vol. 22, pp. S499–S504, 1998.

[3] A. Roberts, "*No TitleΧίτλερ & Τσώρτσιλ*," Undang. Republik Indones. Nomor 20 Tahun 2003 Tentang Sist. Pendidik. Nas. Dengan Rahmat Tuhan Yang Maha Esa Pres. Republik Indones., no. 1, pp. 1–26, 2003.

[5] T. Yang and C. Kuo, "*A hierarchical AHP/DEA methodology for the facilities layout design problem*," Eur. J. Oper. Res., vol. 147, no. 1, pp. 128–136, 2003.

[6] M. bazargan Lari, "*Layout designs in cellular manufacturing*," Eur. J. Oper. Res., vol. 112, no. 2, pp. 258–272, 1999.

[7] U. Tarigan and M. B. Ambarita, "*Design and Simulation Plant Layout Using Systematic Layout Planning Design and Simulation Plant Layout Using Systematic Layout Planning*."

[8] S. Bock and K. Hoberg, "*Detailed layout planning for irregularly-shaped machines with transportation path design*," Eur. J. Oper. Res., vol. 177, no. 2, pp. 693–718, 2006.

[8] K. Ueda, N. Fujii, I. Hatono, and M. Kobayashi, "*Facility layout planning using self-organization method*," CIRP Ann. - Manuf. Technol., vol. 51, no. 1, pp. 399–402, 2002.

[9] K. Schlee, J. Ristow, S. C. M. Blvd, C. Hubert, and P.O. Box, *"Proceedings of the 2005 Winter Simulation Conference K. Schlee, S. Gangadharan, J. Ristow, J. Sudermann, C. Walker, C.Hubert,"* Assembly, no. Hubert 2003, pp. 1265–1274, 2005.

[10] S. K. Deb and B. Bhattacharyya, "*Fuzzy decision support system for manufacturing facilities layout planning,"* Decis. Support Syst., vol. 40, no. 2, pp.305–314, 2005.

[11] D. I. Patsiatzis and L. G. Papageorgiou, "*Optimal multi-floor process plant layout,"* Comput. Chem. Eng., vol. 26, no. 4–5, pp. 575–583, 2002.

[12] A. Asef-Vaziri and G. Laporte, "*Loop based facility planning and material handling,"* Eur. J. Oper. Res., vol. 164, no. 1, pp. 1–11, 2005.

[13] D. Raman, S. V. Nagalingam, and G. C. I. Lin, "*Towards measuring the effectiveness of a facility layout*," Robot. Comput. Integer. Manuf., vol. 25, no. 1, pp. 191–203, 2009.

[14] Y. Ojaghi, A. Khademi, N. M. Yusof, N. G. Renani, and S. A. H. B. S. Hassan, "*Production layout optimization for the small and medium scale food industry*," Procedia CIRP, vol. 26, pp. 247–251, 2015.

[15] J. Bukchin, E. M. Dar-El, and J. Rubinovitz, "*Mixed model assembly line design in a make-to-order environment*," Comput. Ind. Eng., vol. 41, no. 4, pp.405–421, 2002.

[16] A. R. S. Amaral, "*On the exact solution of a facility layout problem*," Eur. J. Oper. Res., vol. 173, no. 2, pp. 508–518, 2006.

[17] J. H. Jo and J. S. Gero, "*Space layout planning using an evolutionary approac*h," Artif. Intell. Eng., vol. 12, no. 3, pp. 149–162, 1998.

[18] M. Solimanpur and A. Jafari, "*Optimal solution for the two-dimensional facility layout problem using a branch-and-bound algorithm*," Comput. Ind. Eng., vol.55, no. 3, pp. 606–619, 2008.

[19] H. Huang, S. A. Irani, and C. A. Mount-Campbell, "*FACILITY LAYOUT USING LAYOUT MODULES"* Presented in Partial Fulfillment of the Requirements for the Degree Doctor of Philosophy.

[20] Richard Muther Systematic-Layout-Planning-SLP-4th- edition. Mc Graw, 1955 – hard copy.

[21] Work-Study ILO Publication -hard copy.