Optimization of Plant Layout for Small and Medium Scale Industries

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***Abstract*:- To sustain in today's economy, manufacturing plants must be able to run efficiently and respond quickly to changes in the product mix and demand. The efficiency can be improved by improving various parameters i.e. reducing transportation distance, reducing waste generated during process, utilizing men power, reducing energy consumption by improving manufacturing method, etc.**

In this proposed method optimization is achieved by reducing the material handling distance by modifying SLP (Systematic Layout Planning) method using previous production data. This method is useful for small and medium scale industries which have various manufacturing flows based on the customization demand. As a case study a medium scale industry manufacturing PP (Polypropylene) bags is taken under consideration.

1. INTRODUCTION

Planning the layout at the outset before building the plant or office is the best way to reduce the costs remarkably. Producing products or delivering services at high quality, with less cost and in short time using the fewest resources is the objective of properly managing a facility [2]. Following are the main aspect of the research:

- To organize the product lines in order to establish a streamline material flow.
- To reduce movement of workers, raw material and equipment
- To ensure that the new layout satisfies the essential safety requirements and create safe and comfortable work environment.
- To utilize the available space in an optimal manner.

For this research "Vishawa Industries" is been chosen. **"**Vishwa Industries**"** are the manufacturer and exporter of woven sack which are useful for packaging of grains, sugar, fertilizer, jaggery powder and cement etc. The manufacturing unit mainly consists of warehouse, tape plant, loom machine, laminating machine, gusset machine, testing machine, BCS machine, printing machine, liner inserting process, stitching, baling and storage. Following are the processes explained which are useful for understanding the paper.

- BCS Machine (Bags Stitching Cutting)

Fabric roll from the warehouse is set up on the BCS machine. The roll then cut into bag of required length and then stitched at the bottom of the bag. Every bag has to go under this process. Capacity of the machine is 30-40 bags/min.

- Printing Machine

A 3 color printing machine is used in the plant. One bag at a time is fed to the machine. Worker collect colored bag manually and make a pile of them. Coloring is not mandatory process as it depends on the customer's requirement.

- Liner inserting process

Liner is the thin polythene bag which is inserted in the PP bag manually by a certain mechanism. Many times customer demands for the liner. Liner bags mainly required for the jiggery plant as liner prevents moisture to enter in the bag hence keep it for long time.

- Stitching

Stitching at the top of the bag is done to increase the strength. Sometimes customers don't ask for stitching as it is not required for the purpose also bags without stitching costs less.

- Baling

Baling is the process of pressing bags, generally 500 or 1000 bags at a time to make mass compact hence less space occupied for storage and easy to transport.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 9 Issue 12, December-2020

The industry manufactures PP bags based on the customer requirements. Following are the various requirements of the customers.

1. Printing + Liner + Stitching
2. Printing + Liner
3. Printing + Stitching
4. Liner + Stitching
5. Only Printing
6. Only Liner
7. Only Stitching

Several facility planning techniques could be used to develop a new layout or improve the current layout such as Systematic Layout Planning (SLP), Pairwise Exchange Method (PEM), Graph Based Theory (GBT), Dimensionless Block Diagram (DBD), Total Closeness Rating (TCR), etc. In this study, SLP facility planning methods have been used to design the sustainable layout.

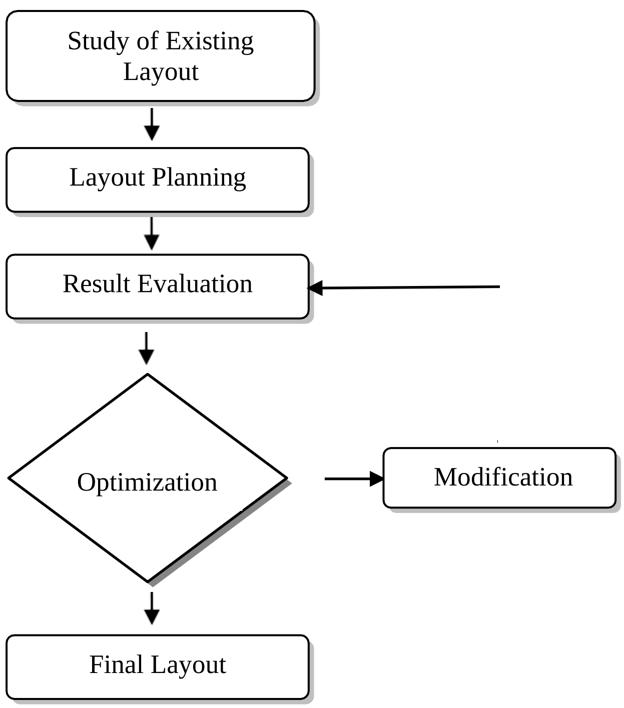

Figure 1: Flow chart

2. PROBLEM STATEMENT

In Systematic Layout Planning (SLP), it is difficult to determine layout/flow of process when relationship chart gives same closeness for more departments.

Hence, to modify relationship chart to optimize material handling distance, when the plant departments have same closeness.

3. METHODOLOGY

3.1 Study of Existing Layout

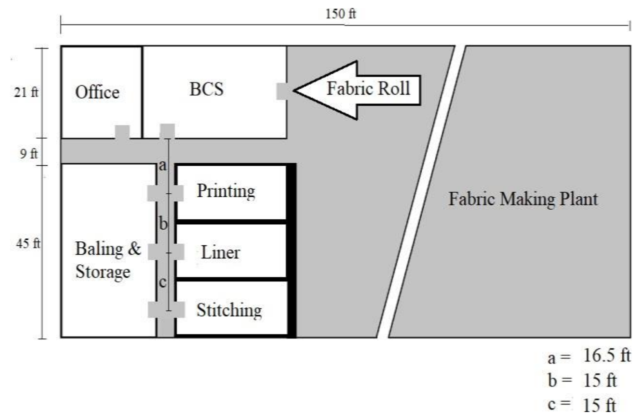

Figure 2: Existing layout

Figure 2 is the existing layout of industry, which have 2 sections. first is fabric making plant and second is bag converting plant. In the bag converting plant customized bags are made according to order.

Table 1: Distance travelled before optimization

No	Operation	Distance
1.	Printing + Liner + Stitching	16.5+15+15=46.5
2.	Printing + Liner	16.5+15=31.5
3.	Printing + Stitching	16.5+15+15=46.5
4.	Liner + Stitching	16.5+30+30=46.5
5.	Only Printing	16.5
6.	Only Liner	16.5+15=31.5
7.	Only Stitching	16.5+15+15=46.5

3.2 Layout Planning

In layout planning SLP technique is used, REL chart is used to develop the relationship diagram and the space relationship diagram. For this study, both are shown in figure 3 and figure 4, respectively.

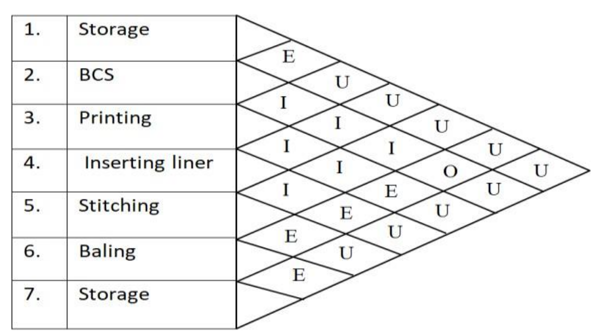

Figure 3: Relationship chart

Where, Alphabets represents closeness as follows A= Absolutely necessary
E= Especially important
I= Important
O= Ordinary closeness okay
U= Unimportant
X= Undesirable

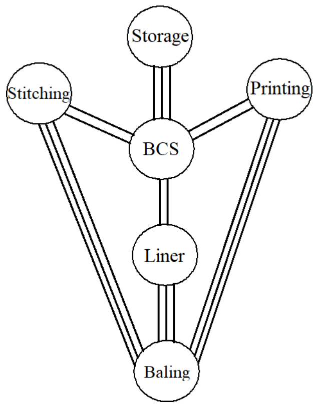

Figure 4: Relationship diagram

3.3 Result Evaluation

From figure 3 and figure 4 it is clear that BCS unit has to place at the center as is most important and second importance is given to baling machine as every product has to go under this process.

Now, due to layout constrain stitching, liner and printing departments has to place one after another but, the problem is stitching, printing and liner departments have same closeness to the BCS unit (see figure 3) so there is uncertainty of placing these departments closer to the BCS unit. This uncertainty makes layout planning complex.

As stated in the problem statement to optimize material handling distance, when the plant departments have same closeness. modification of the relationship chart has to be done to clear out uncertainty about layout.

3.4 Modification

So, as to clear out uncertainty, relationship chart is modified on the basis of previous production data. Since the industry has started in 2016, from then it required an average of 720 tons of material every year. The material is in the form of plastic granules which then processed through out the process. Table 2 shows the percentage of the weight transferred through various process throughout the year.

Table 2: Production data

Customization	**Year 2016-2020**					**Avg**
	16	17	18	19	20	
Liner +Printing Stitching	22.9	17	22	20.5	17.5	19.9
Liner +Printing	11	8	9.5	11.5	10	10
Liner +Stitching	26.3	24.5	28	25	26	25.9
Printing +Stitching	15.5	16	13.2	14	11	12.9
Only Liner	1.2	3	1.2	5	5.2	3.12
Only Printing	14	7	6.5	5	6	7.7
Only Stitching	21	22.3	16.5	17.5	19	19.3

At an average of 100 kg of material (nearly about 1000 bags) i.e. 1 lot is moved at a time from one department to another. Table 3 shows the distance travelled by the material before optimization for each customized process though out the year.

Table 3: Total distance travelled before optimization

Customization	Total weight (ton)	No of lots	Distance travelled per lot (ft)	Total distance travelled (ft)
Liner +Printing Stitching	143.28	1432	46.5	66588
Liner +Printing	72	720	31.5	22680
Liner +Stitching	186.48	1864	46.5	86676
Printing +Stitching	92.88	928	46.5	43152
Only Liner	22.464	226	16.5	3729
Only Printing	55.44	554	31.5	17451
Only Stitching	138.96	1389	46.5	64588
			Total	304864

To obtain optimized layout, the modified relationship chart is used. In modified relationship chart average percentage weight travelled through various customization from table 2 is used. The closeness value and average percentage of material weight is written in the same block. Figure 5 shows modified relationship chart.

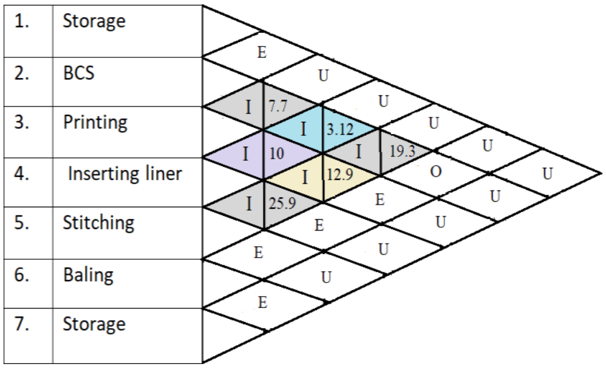

Figure 5: Modified relationship chart

From the above figure, adding percentage values as a normal value for individual departments:

Printing = 7.7 + 10 + 12.9 = 30.6

Inserting Liner = 10 + 3.12 + 12.9 = 26.02

Stitching = 25.9 + 12.9 + 19.3 = 58.1

The above data clearly shows that maximum value is for stitching department and minimum is for the liner department. Maximum the value maximum is the material flowing through the department so, having stitching department first to the BCS machine and liner inserting department last will decrease the material handling distance i.e. optimize the layout. Using this information, modified layout is proposed (see figure 6).

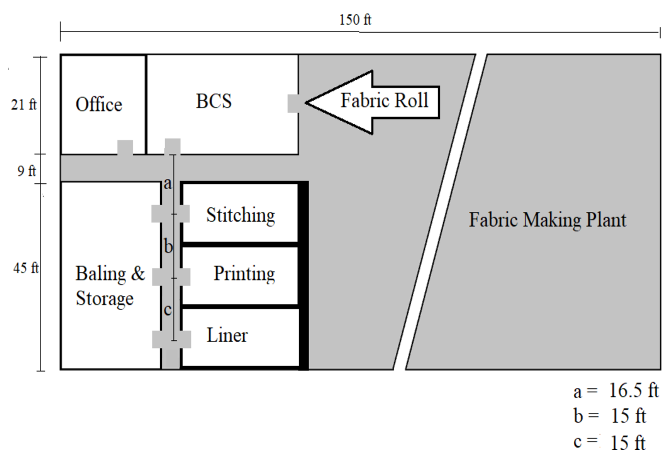

Figure 6: Modified layout

4 RESULT AND DISCUSSION

In the modified layout (see figure 6) position of three departments is altered as to obtain optimization. After modification the material handling distance changes for each customization. The table (see table 4) shows the material handling distance after modification.

Table 4: Distance travelled after optimization

No	Operation	Distance
1.	Printing + Liner + Stitching	16.5+15+15=46.5
2.	Printing + Liner	16.5+15+15=46.5
3.	Printing + Stitching	16.5+15=31.5
4.	Liner + Stitching	16.5+15+15=46.5
5.	Only Printing	16.5+15=31.5
6.	Only Liner	16.5+15+15=46.5
7.	Only Stitching	16.5

Once getting material handling distance for each customization the total material handling for a year is calculated (see table 5).

Table 5: Total distance travelled after optimization

Customization	Total weight (ton)	No of lots	Distance travelled per lot (ft)	Total distance travelled (ft)
Liner +Printing Stitching	143.28	1432	46.5	66588
Liner +Printing	72	720	46.5	33480
Liner +Stitching	186.48	1864	31.5	58716
Printing +Stitching	92.88	928	46.5	43152
Only Liner	22.464	226	31.5	7119
Only Printing	55.44	554	46.5	25761
Only Stitching	138.96	1389	16.5	22918
			Total	257734

The total material handling distance before optimization was 304864 ft while after optimization is 257734 ft. There is reduction of 15.45% which is equal to 47130 ft. The reduction in the material handling distance eventually leads to reduction in material handling time hence, increase in the productivity.

5 CONCLUSION

The goal of this study is to develop a new production layout for a PP bags manufacturing industry in view of the need to increase the production capacity using facility planning and design techniques.

The first step is by using SLP method, relationship chart and relationship diagram are obtained. Evaluation is done to check weather optimized layout is possible or not. If layout cannot be optimized then modification of relationship chart is necessary. The evaluation shows that due to some constrains the optimization based on the regular method is not possible.

The new layout obtained after modification of relationship chart using previous year's production data

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 9 Issue 12, December-2020

gave optimized layout. In optimized layout there is reduction of 15.45% in material handling distance throughout the year.

6 FUTURE SCOPE AND DISADVANTAGES

When relationship chart gives same closeness to more departments, then it is difficult to decide flow of material. thus, modified method is used when regular method fails to optimize layout.

The main disadvantage of the modified method is industries need to have previous year's production data, without it modified method cannot be used. Another disadvantage is, this modified method will not be effective when previous production values shows more fluctuation.

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