Improvement Plant Layout of Production Line in Textile Company: A Case Study

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Abstract

This research took place of a textile company, its primary object was to design a layout for a specific area of production line, applying methods of plant distribution. The project began with the description of basic theories which were used to enable the research, continuing realizing diagnosing the production system where the flow of materials was examined, and the current layout was observed. Alternative solutions were created and a practicable solution for the layout was established by using Systematic Layout Planning; to test the solution mentioned above, the quantitative methods called Computer Relative Allocation of Facilities Technique and Computerized Relationship Layout Planning were applied. Furthermore, a final solution for the layout was proposed in which the organization of two working departments was designed with a production flow of the U-type.

Keywords
Plant distribution, Lay Out, SLP, CORELAP, CRAFT

1. Introduction

The distribution in plant is the ordering logical of the industrial elements (work force, means of work, work object and area), so that it follows the route of the productive flow through the production line. This includes the delimitation of the corridors and workstations, as well as the corridors of circulation (Muther 1973). The distribution in plant consisted in the physical management of the factors and industrial elements that participate in the productive process of the company, in the distribution of the area, in the determination of the relative figures and location of the different departments. The main objective is that this provision of elements be efficient and carried out in such a way as to contribute satisfactorily to the achievement of the purposes set out in the company (De la Fuente and Quesada 2005).

An analysis in the production process of the company under study, it shown that there are delays in the transport of the work object because the departments are not distributed sequentially. Sand identified that there are two posts working to perform the same tailoring operations. In addition, one of the posts works shows congestion in the hallways. The workspaces do not meet the dimensions established in the regulation and that presents accumulations of product in process (Leyva et al. 2018). By what do not meet the principles of distribution in the plant, thus having a problem with the organization of facilities (Lorente el al. 2018).

2. Materials and Methods

Many authors have used plant distribution methods to optimize the placement of workstations. The method is initially assumed Systematic Layout Planning (SLP) proposed by Muther (1973). That based on the flow of production are located the jobs. In addition, it is analyzed what is proposed by Van Donk and Gaalman (2004); Liu and Chen (2008); Wiyaratn and Watanapa (2010); Wiyaratn et al. (2013), which have applied this methodology in different companies, managing to optimize the distribution of the departments. In the case of Lee (1966), proposes the organization of workspaces through the Method Computerized Relationship Layout Planning (CORELAP), developed a program that establishing a criterion for the proper location of each or departments, based on the Total Closeness Rating (TCR). The authors Devis (1967) and Deisenroth (1971), develop the method through the sum of all numeric values assigned to proximity relationships, referred to in the relational diagram of activities. Moreover Khalil (1973) analyzes the method Computer Relative Allocation of Facilities Technique (CRAFT), which, of the possible iterations of the departments decides the location through the lower cost of transport of the work object. Exposed by Scriabin and Vergin (1975); Houshyar (1991); Liggett (2000). Hari Prasad et al. (2014), they examine the flow of materials from one department to another and the cost of transporting the work object through the stations.

In Figure 1, it shows the sequence of activities for the application of the methods of distribution in plant. It starts with the development of the production flow to know the technological sequence, then it applies the SLP that determines the iterations between the workstations. Having as input the relationship matrix developed in the previous method applies the CORELAP, finally apply the CRAFT with which is demonstrated the optimal distribution in plant with a minimum cost of transport of the object of work, for each of the positions of work.

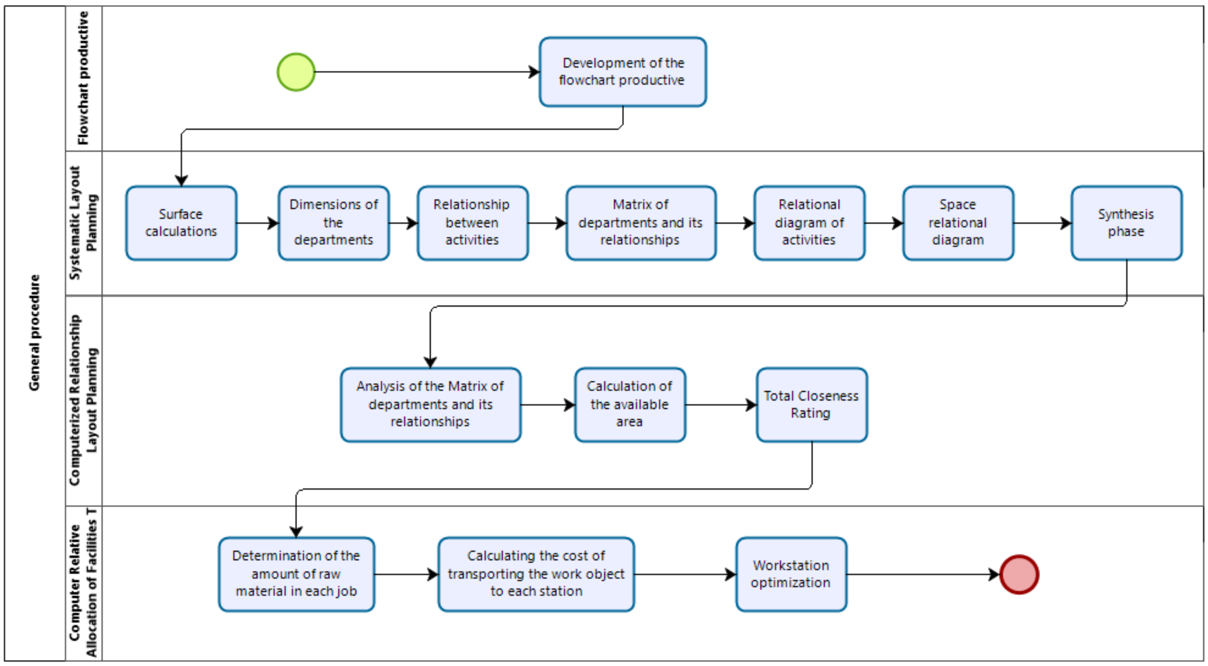

Figure 1. General procedure

3. Result and Discussion

The methodologies were applied in a textile company, dedicated to the manufacture, sale and commercialization of wool-based garments wholesale and retail. The following is evidence of the development of methods for plant distribution in the company under study, which was divided into four phases.

Phase 1 Flowchart productive

The production flow is carried out to identify and sequence the activities carried out within the area under study, with the purpose of graphically representing the chronological succession of the trajectory of the work object, how shown in Figure 2.

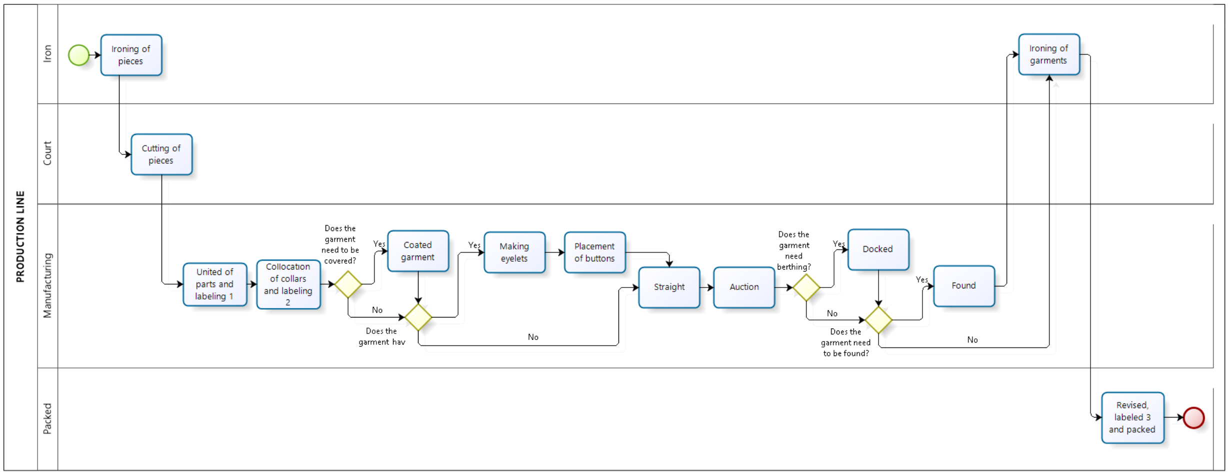

Figure 2. Flowchart productive

Phase 2 Method Systematic Layout Planning

Surface calculations

We made the calculation of surfaces to know the space needs of each area, based on the technical sheets of machinery and requirements of each activity individually, also considered the legal regulations to have safe spaces work.

Table 1. Surface calculations

1. Raw Material Shelving	
Dimensions (m)	2,40 x 0,90

2. Ironing Area			
Workstations, machines and equipment	Amount	Dimensions (m)	Dimensions T (m)
Great snowboard	1	5,60 x 3,90	10,90 x 4,50
Small Iron	3	5,30 x 3,15	
Production table in large process	2	2,90 x 0,50	
Production table in small process	6	1,50 x 0,50	

3. Cutting Area			
Workstations, machines and equipment	Amount	Dimensions (m)	Dimensions T (m)
Cutting table	2	2,45 x 1,85	4,90 x 2,65

4. Sewing Area1			
Workstations, machines and equipment	Amount	Dimensions (m)	Dimensions T (m)
Overlock Machine	5	4,40 x 3,60	7,00 x 6,80
Attached machine	3	4,40 x 2,40	
Quasar Machine	2	4,40 x 1,20	
Remeshing Machine	5	5,50 x 2,40	
Production table in Process	2	1,50 x 0,50	

5. Sewing Area2			
Workstations, machines and equipment	Amount	Dimensions (m)	Dimensions T (m)
Coating machine	4	4,40 x 2,40	4,60 x 4,40
Ojala Machine	1	2,20 x 1,20	
Button machine	1	2,20 x 1,20	
Production table in Process	2	1,10 x 0,50	

6. Sewing Area3

Workstations, machines and equipment	Amount	Dimensions (m)	Dimensions T (m)
Straight machine	4	4,40 x 2,40	4,60 x 4,40
Zigzag machine	1	2,20 x 1,20	
Finisher Machine	1	2,20 x 1,20	
Production table in Process	2	1,10 x 0,50	

7. Sewing Area4			
Workstations, machines and equipment	Amount	Dimensions (m)	Dimensions T (m)
Mooring machine	2	4,40 x 1,20	4,40 x 3,40
Shelling machine	2	4,40 x 1,20	
Production table in Process	2	1,10 x 0,50	

8. Packaging Area			
Workstations, machines and equipment	Amount	Dimensions (m)	Dimensions T (m)
Packing table	2	2,45 x 1,50	4,90 x 2,30

The machines were grouped considering the productive flow, especially the sewing machines, where four areas were created, which joined sequential activities in two groups and not necessarily sequential in two other groups. It also considered the area for the production in process of the different departments.

Table 2. Dimensions of the departments

No	Departments	Dimensions (m)	Area (m^2)
1	Raw material shelving	2,40 x 0,90	2,16
2	Ironing Area	10,90 x 4,50	49,05
3	Cutting Area	4,90 x 2,65	12,98
4	Sewing Area 1	7,00 x 6,80	47,60
5	Sewing Area 2	4,60 x 4,40	20,24
6	Sewing Area 3	4,60 x 4,40	20,24
7	Sewing Area 4	4,40 x 3,40	14,96
8	Packaging Area	4,90 x 2,30	11,27

Relationship between activities

For the relationship between activities was based on the grouping made in the calculation of surfaces, with the help of this list was made a relational matrix of activities shown in Figure 3. The matrix shows the activities that must be approached and those that must be removed, the reasons or causes by which they relate (value of the motive). The required area is also shown for each department.

Table 3. Proximity ratings

Convenience	Code	Representation
Absolutely necessary	A	
Especially Important	E	
Important	I	
Ordinary	O	
No importance	U	
Undesirable	X	

Table 4. Proximity justifications

Code	Reason
1	Productive flow
2	Supply of materials
3	Inspection and control of the product

The matrix shows the departments and its relationships by which they should be kept close or should be removed, the motives or causes by which they relate (value of the motive) and the area required for each department.

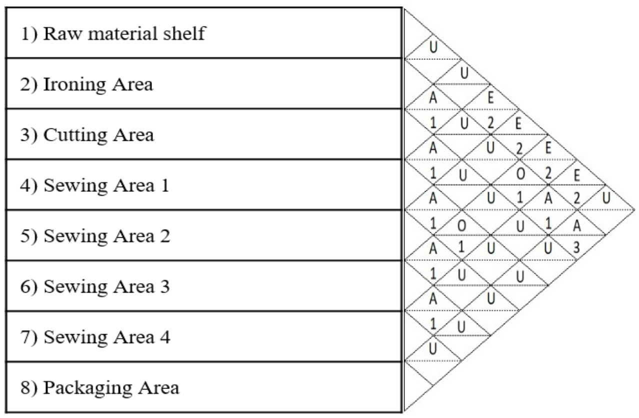

Figure 3. Relationship matrix

Relational diagram of activities

The relational diagram of activities was carried out with the objective of reflecting in the form of diagram the information contained in the relational matrix of activities. We started drawing the most important activities (type A relationship and type E relationship). Figure 4 indicates the diagram with all the relationships between the activities.

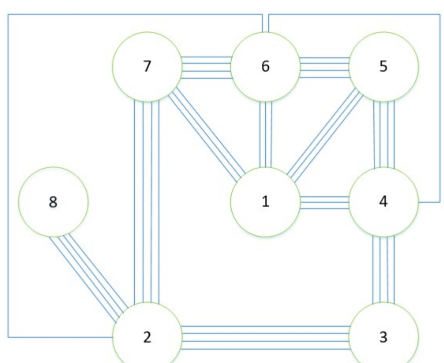

Figure 4. Relational diagram of activities

Space relational diagram

After having obtained the dimensions of the different areas of work and carried out the relational diagram of activities, it proceeded to elaborate the relational diagram of spaces, assigning the necessary surface to each activity and maintaining the relations between activities. A contrast was made with the available space of the place of implantation and the first sketch of distribution in plant was obtained.

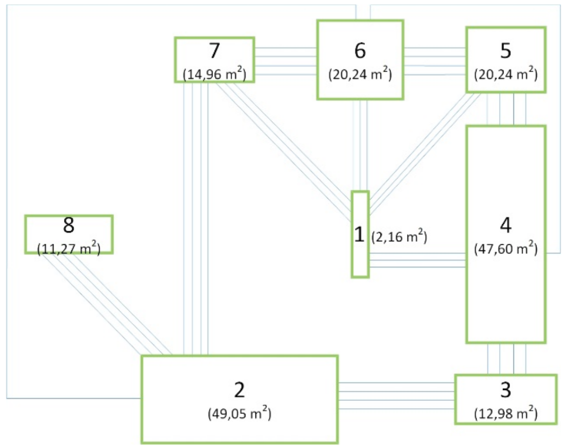

Figure 5. Space relational diagram

Synthesis phase

Within the phase of synthesis of SLP was considered influencing factors for the design of distribution in plant:

1. Within the production line, the activity prior to the area under study is up the steps, so it is necessary that the following activity is as close as possible, with the objective of reducing transport times of the object of work.
2. Within the production line, the post-study area activity and the last is the finished product storage, after performing a graphical analysis it was determined that the shortest distance to be traversed to the storage area is exiting the terrace and lowering the other steps that the company has.
3. We organized the productive flow focused on the most important produced.

Two definitive alternatives of distribution in plant were created, for which it was departed from the relational diagram of spaces and it was modified considering the internal requirements of comfort and safety of the personnel in the workstation.

Phase 3 Method Computerized Relationship Layout Planning

This improvement proposal also introduced data from the plant distribution problem, such as: the number of departments, the names of the departments with its respective area expressed in square meters, the total available surface of the facilities, as shown in Table 5.

Table 5. TCR calculation

Name of the department	TCR	Surface
Raw Material Shelving	27	2.16
Ironing Area	23	49.05
Cutting Area	26	12.98
Sewing Area 1	25	47.6
Sewing Area 2	26	20.24
Sewing Area 3	22	20.24
Sewing Area 4	23	14.96
Packaging Area	18	11.27

It also entered values of the weight of the proximity relationships between departments, where the high value of the constant means that it is important that two departments are placed together, on the contrary, a constant value very small means it's not important that the departments meet. It was then necessary to enter the matrix of relationships between activities, this matrix was previously elaborated in the SLP method, where the type of relationship was specified: Absolutely Important (A), Especially Important (E), Ordinary (O) and non-important relationship (U).

Finally, the results were generated from where the following information was obtained:

1. The order of importance of the departments depending on the affinity with all others according to the weights previously introduced. The order of importance is known as TCR (Total Closeness Rating).
2. It also looks at the required surface (calculated by the program) which was smaller than the available surface. The presentation of results.
3. The calculation of the iterations consisting of two iterative processes: The calculation of the order in which the departments and the placement the most appropriate position
4. The graphical representation of the location of each one of the departments

Phase 4 Method Computer Relative Allocation of Facilities Technique

The CRAFT method was developed with add-ins in excel and started with data entry about the problem, such as the name of the project, the number of departments to implement and distance measurement unit. The information filled out about the number of departments to be implemented is the same as the SLP method, therefore, this information was transcribed from the previous method. The unit of measure chosen were the meters as in previous method.

After completing the initial data about the problem, an excel sheet was automatically generated where the length and width of the new installations were entered, as well as the name of the departments and its occupied area. In addition, information about the productive flow was integrated, it involves the transfer of information from the department and the department J. In the Table 6 shows information about the departments and the flow data. The data were entered as a number, where the highest value is considered more important to move.

Table 6. Matrix From–To

Department *i* (*From*)	**Department *j* (*To*)**	**Flow data**	**Value entered**	**Type of relationship**
Raw material shelf – D1	Cutting Area 1 – D4	Threads and needles	15	Important
	Sewing Area 2 – D5	Threads and needles	15	Important
	Sewing Area 3 – D6	Threads and needles	15	Important
	Sewing Area 4 – D7	Threads and needles	15	Important
Ironing Area – D2	Cutting Area – D3	Pieces	18	Very Important
	Packaging Area – D8	Garments	18	Very Important
Cutting Area – D3	Sewing Area 1 – D4	Pieces	18	Very Important
Sewing Area 1 – D4	Sewing Area 2 – D5	Pieces	18	Very Important
	Sewing Area 3 – D6	Pieces	12	Ordinary
Sewing Area 2 – D5	Sewing Area 3 – D6	Pieces	18	Very Important
Sewing Area 3 – D6	Ironing Area– D2	Garments	12	Ordinary
	Sewing Area4 – D7	Pieces	18	Very Important
Sewing Area 4 – D7	Ironing Area– D2	Garments	18	Very Important

System implementation feasibility analysis

The evaluation of the proposed plant distribution was carried out in two ways, qualitatively and quantitatively. qualitatively, the improvements in the plant distribution design proposed.

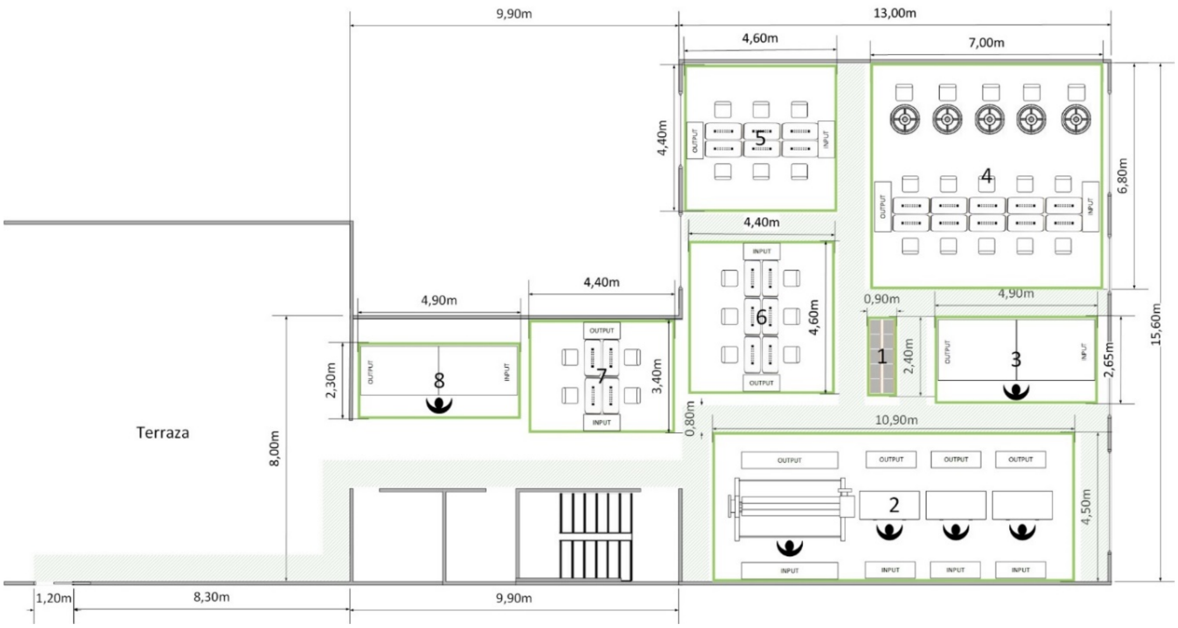

Figure 6. Distribution of plant final

After analyzing the distribution solutions in distribution of plant final, it is important to emphasize that these methods provided an order of the departments to be implemented, where they establish on a productive flow the allocation of the specific area of each department. Supported by software's, it is they generate a rectangular area of installations where they want to implement the production line. It was necessary to make a readjustment to the results obtained by the programs to obtain a final solution of distribution in plant. The final proposal for plant distribution is shown in the figure 6, where the length and width measurements of each department are displayed, the corridors for personnel circulation and the location of the machines.

Table 7. Improvements to the plant distribution

Plant Distribution Principles	Initial distribution	Proposed distribution
Assembly integration	Non-location specific materials	Material Shelving
Minimum distance traveled	Existence of two work areas (ground floor and second floor) with the same operations	Reduction of travel distances and integration of the Departments in a single site
Flow of materials	Location of empirical machines Excessive accumulation of materials in process	Sequence of operations Creation of Department Works
Cubic space	Excessive distances to traverse in the workflow	Effective use of available space
Satisfaction and security	No existence of halls in the work center Insufficient space between machines	Creating hallways Safe working Spaces
Flexibility	Little space for reorganization of operations	Ability to adjust operations
Order	Distant operations and disorganization in the process	Departments of work ordered according to the sequence of activities

Quantitatively, the transport costs of the work object obtained using the CRAFT method were analyzed. For the resolution of the problem it was assumed that the transport costs between the Departments are the same, so we entered an assessment equal to one in the cost matrix of the software.

Table 8. Cost reduction percentage

Plant distribution	Transport costs of the work object	Cost reduction percentage
Current	2458	36,82%
Proposal	1553	

After examining the transport costs of the work object in the current distribution and the proposed distribution, it is clearly shown that it is less expensive to transport the work object with the proposed plant distribution, having a reduction of 36.82 %.

4. Conclusions

1. A U-shaped material flow was used to optimize the space used with greater control over production processes and direct communication with previous and subsequent activities to the area under study.
2. Systematic Layout Planning was applied distribution plant where a feasible distribution solution was generated that was obtained, after having evaluated alternatives of solution in conjunction with the owner of the company and the production personnel.
3. Methods the quantitative CRAFT and CORELAP with the purpose of contrasting the solution obtained with the SLP method, making the three methods of distribution in plant coincide in their results.
4. The proposal of distribution in final plant allowed to define the trajectory of the object of work of the area of study, distributing the spaces of work by the creation of departments clearly identified and ordered.
5. The proposed plant distribution was evaluated in a qualitative and quantitative way, where improvements were visualized by reducing the cost of transport of the work object by 36.82%.

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