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REDESIGN OF THE MANUFACTURING PLANT "EL CEBÚ LTDA." TROUGH PROCESS ORIENTED LAYOUT

REDISEÑO DE LA PLANTA MANUFACTURERA "EL CEBÚ LTDA." A TRAVÉS DE LAYOUT ORIENTADO AL PROCESO

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Abstract: The proper distribution of departments in plants, both products and services, are key decisions that allow organizations to determine the long-term efficiency of operations, in addition to establishing competitive parameters in terms of capacity, processes, flexibility and costs, without neglecting advantages such as quality of life at work, customer contact and image, Tompkins, & White (2013). The purpose of the project is to develop an economic layout that satisfies the company's competitive requirements, making the most of the spaces, equipment and people it has; to improve the flow of information, materials and people, as well as the safety of the working conditions of the collaborators and the interaction with the client; this allows the company to adapt to future changes that may arise in terms of new products, new processes, new machinery and equipment, new technologies, new materials, among others.
This document presents a proposal for redesigning the distribution of the plant, based on the material handling costs currently handled by the company, with the objective of minimizing such costs and maximizing the resources used in the manufacture of electric fences, in El Cebu LTDA, through the implementation of a Layout oriented to the process.

Key Words: Layout, Distribution by process, production, material handling costs.

Resumen: La adecuada distribución de los departamentos en las plantas, tanto de productos como de servicios, son decisiones claves que permiten a las organizaciones determinar la eficiencia a largo plazo de las operaciones; además de establecer parámetros competitivos en cuanto a capacidad, procesos, flexibilidad y costos, sin dejar de lado ventajas como la calidad de vida en el trabajo, el contacto con el cliente y la imagen, Tompkins & White (2019). El propósito del proyecto es desarrollar un layout económico que satisfaga los requerimientos competitivos de la empresa, aprovechando al máximo los espacios, equipos y personas con que cuenta; para lograr mejoras en el flujo de información, materiales y personas, así como la seguridad de las condiciones de trabajo de los colaboradores y la interacción con el cliente; lo que permite adaptarse a los cambios futuros que se puedan presentar en cuanto, a nuevos productos, nuevos procesos, nueva maquinaria y equipos, nuevas tecnologías, nuevos materiales, entre otros.

Este documento presenta una propuesta de rediseño de distribución de la planta, basado en los costos de manejo de material que actualmente maneja la empresa, con el objetivo de minimizar

dichos costos y maximizar los recursos utilizados en la manufactura de cercas eléctricas, en El Cebú LTDA, a través de la implementación de un Layout orientado al proceso.

Palabras Clave: Layout, Distribución por proceso, producción, costos de manejo de materiales.

Resumo: A distribuição adequada dos departamentos nas fábricas, tanto de produtos quanto de serviços, são decisões importantes que permitem às organizações determinar a eficiência das operações a longo prazo; Além de estabelecer parâmetros competitivos em termos de capacidade, processos, flexibilidade e custos, sem descurar vantagens como qualidade de vida no trabalho, contato com o cliente e imagem [1]. O objetivo do projeto é desenvolver um layout econômico que atenda aos requisitos competitivos da empresa, aproveitando ao máximo os espaços, equipamentos e pessoas que possui; melhorar o fluxo de informações, materiais e pessoas, bem como a segurança das condições de trabalho dos colaboradores e a interação com o cliente; permitindo adaptar-se a mudanças futuras que possam surgir em termos de novos produtos, novos processos, novas máquinas e equipamentos, novas tecnologias, novos materiais, entre outros.
Este documento apresenta uma proposta de reprojeto da distribuição da planta, com base nos custos de manuseio de materiais que a empresa administra atualmente, com o objetivo de minimizar os referidos custos e maximizar os recursos utilizados na fabricação de cercas elétricas, em El Cebú LTDA , por meio da implementação de um layout orientado ao processo.

Palavras-chave: Layout, distribuição por processo, produção, custos de manuseio de materiais.

INTRODUCTION

Design and Plant Distribution, Stephens (2013); is the physical arrangement of the factors and industrial elements present in the company's production processes, in the contribution of the area and location of the different departments.

The article is the result of a research, which was developed in a company dedicated to the manufacture and distribution of electric fence controls, located in Cogua, Vereda Susagua, and Cundinamarca. It began with the description and diagnosis of the plant, in terms of handling and movement of material, based on times, distances, loads, travel and costs between departments. These data allowed us to know the current cost of transportation and handling of the monthly material. The reference whit more production in the plant (40K) was selected.

Through engineering tools, specific to plant distribution, such as the Activities Relationship Diagrams, which allow to determine the departments that for convenience should be close to each other. Then we proceeded to establish the current costs incurred by the company for handling and transporting annual material in the production of 40 K fences, based on the distances in meters between departments, as well as the weekly loads they handle between them, and the cost of transporting the material per meter traveled. These values are recorded in a "From-To" Diagram for better understanding.

It is possible to determine the departments between which the greatest flow of material moves and therefore, they also generate the greatest cost. The purpose of the investigation is to present a redistribution in an already existing plant, through Layout oriented to the process, in order to reduce costs of material handling. AutoCad and POM software were used as decision-making

tools. Two proposals are presented for alternative distribution of the departments, determining the best option that meets the objectives of the company and minimizes the costs of handling and transportation of material Rivera and Cardona, (2012).

PROBLEM STATEMENT

Layout by Process is given when the production is by lots, as it is the case of each lot of fences that approaches the 100 units of each reference, in Cercas El Cebú Ltda.

This kind of distribution, allows the operators to be trained to perform any task of any process as well as the handling of the machinery available there, because it is generic and little specialized, being able to fit the requirements of each type of product. Baron & Zapata (2012).

The company has been adapting the facilities and processes as it has grown and according to the needs that arise. Management is aware of the poor environmental conditions (ventilation, lighting, noise, tidiness and, cleanliness) in the facilities and recognizes a loss of material of approximately 3%.

It was observed material in process stored, machinery anchored, without safety devices and difficult to move, to move easily, generating little flexibility when changes in the process for new products, poor design of work stations, lack of ergonomics in them, which causes delays in deliveries and high costs in material handling. It was also observed the lack of use of space, as well as the poor condition and infrequent maintenance of machinery and equipment.

In fences EL CEBU Ltda, On the other hand, the inventory of product in process is high, there is an impediment to move in the corridors, since there is material in process in the ground hindering the passage of the collaborators and, consequently, they must move from their work stations to be able to acquire material to carry out their work; this is due to the fact that there are no mechanisms for transporting the material, which would facilitate the work.

Due to the operating conditions and the general objectives of the company, it is important to have a flexible distribution of facilities that allows to attend and to adapt to changes in future new proposals, without affecting the production levels required to meet the demand and without requiring major investments in adjustments or modifications, it is also vital to ensure a smooth flow of the process, without waits and delays for displacements that occur and affect the level of production, Serna (2010).

METHODOLOGY

For the analysis of the distribution problem, the methodology used was the nine steps proposed by Bozer and Meller (1994) to solve plant distribution problems.

When determining the compatibility of the material handling distribution models with the layout problem of the company El Cebú LTDA, it is characterized as a process-oriented layout. After that, the factors that can be modeled as material flow are identified, in this case, the distances in meters between work stations, the loads that are transported, which are measured in number of trips between work areas and the costs of handling materials between them.

In order to better understand the plant distribution that the company currently presents, a diagram was designed where the two plants of the company are observed with their distributions of work areas, proportional to the real size and places of service, as well as the flow of the selected process, within the plant, Fig 1.; it is also determined the space needs for each department and the available plant space.

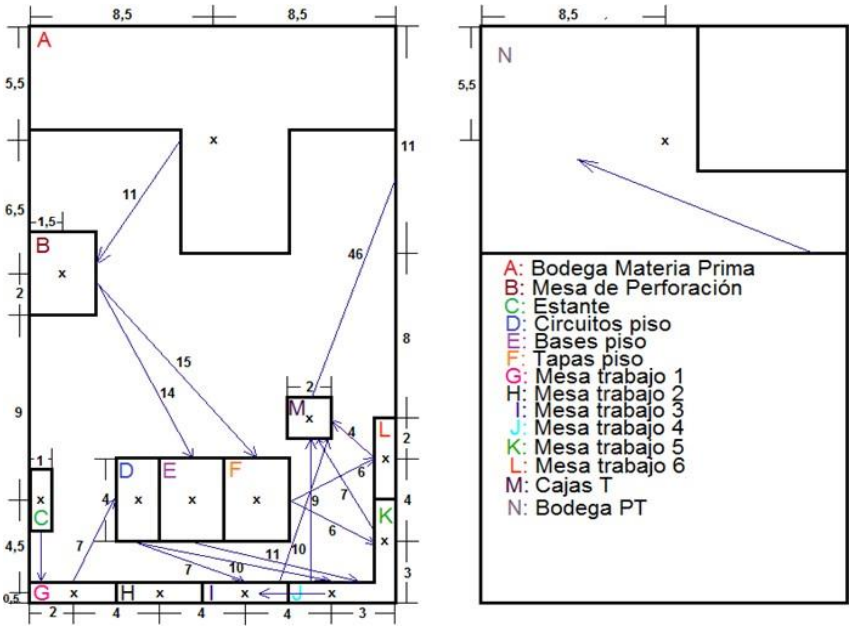

Fig.1. Dimensions of the plant (meters) and current layout of the departments

The production process for the analysis was selected by the manager's criteria, which generates the highest cost of materials handling, due to its high production volume; that is, the product that has the highest demand at present. In this case, it is the production process of 40k electrical controls, which is described in Fig 2.

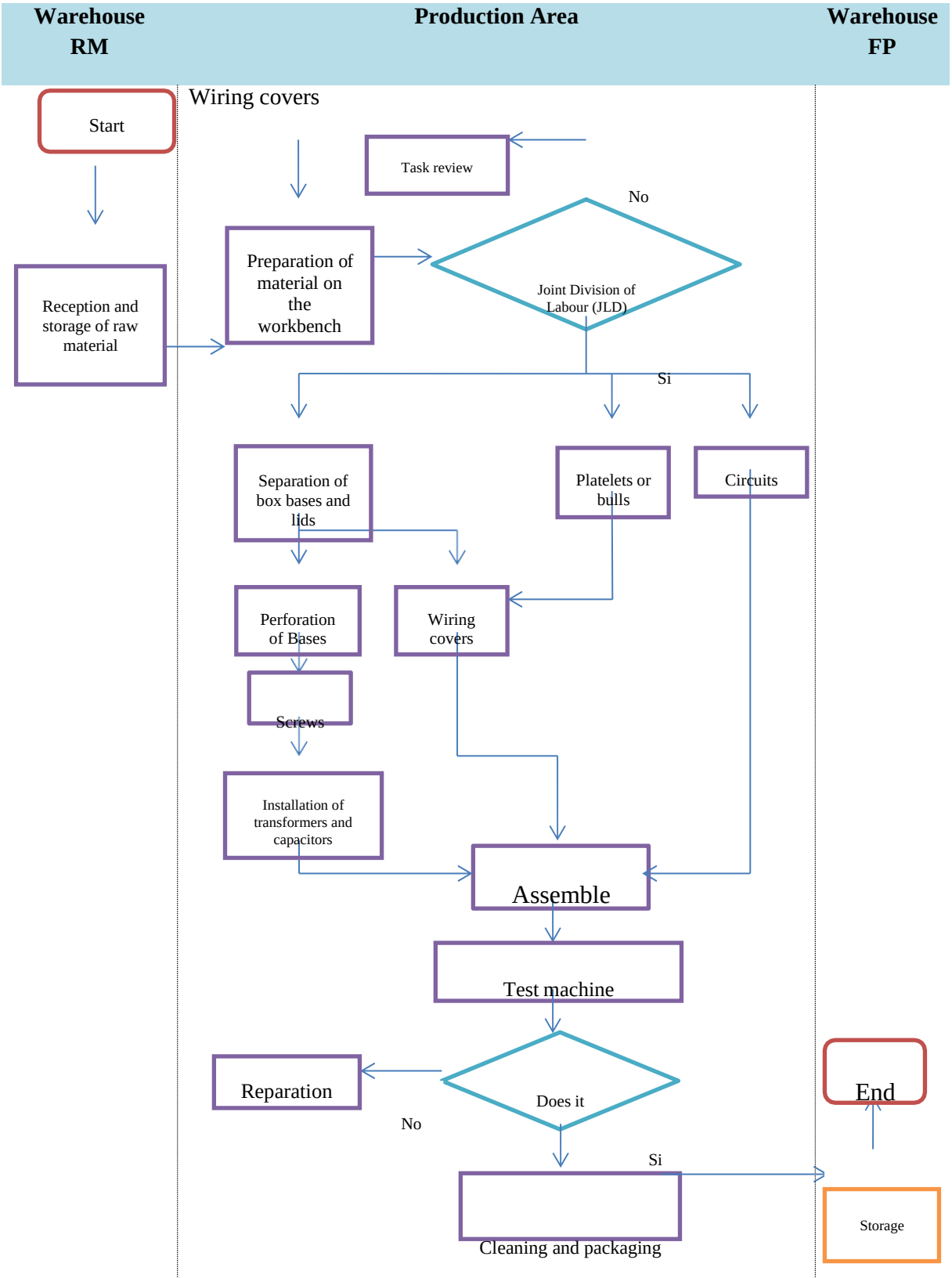

Fig 2. Flowchart of the production process of 40 K electrical controls

It continues with the characterization of the selected production process, with respect to the distribution of work areas, capacity, process, travel times, trips, tasks, loads or lots, in order to find the current costs of material handling generated by the company, for the production of 40 K fences.

As a tool for the analysis of the material flow, From - To Diagrams are used, specifically the following were used: the number of material handling trips per day between two work stations or departments, the diagram that records the distances between areas, and finally the diagram that records the cost of transporting the material between work stations. Niebel (1996)

Consequently, Table 1. records the distances the material must travel between workstations, based on the paths the material makes within the production plant, on the 40K line.

TAB 1. "From-To" Diagram (distances in meters)

	DIAGRAMA DE-HACIA DE DISTANCIAS (Metros)												
	A	B	C	D	E	F	G	I	J	K	L	M	N
A		11	-	-	-	-	-	-	-	-	-	-	-
B	-		-	-	14	15	-	-	-	-	-	-	-
C	-	-		-	-	-	4,5	-	-	-	-	-	-
D	-	-	-		-	-	-	7	10	-	-	-	-
E	-	-	-	-		-	-	-	11	-	-	-	-
F	-	-	-	-	-		-	-	-	6	6	-	-
G	-	-	-	7	-	-		-	-	-	-	-	-
I	-	-	-	-	-	-	-		-	-	-	9	-
J	-	-	-	-	-	-	-	4		-	-	9	-
K	-	-	-	-	-	-	-	-	-		-	7	-
L	-	-	-	-	-	-	-	-	-	-		4	-
M	-	-	-	-	-	-	-	-	-	-	-		60
N	-	-	-	-	-	-	-	-	-	-	-	-	

The diagram is constructed to which records the flow of components, in this case the number of trips made by the material per day. Table 2. shows the number of trips made to produce a batch of 100 electrical controls of 40k daily, according to the flow that follows the product.

TAB 2. "From-To" Diagram (number of trips (batches / diagram))

	DIAGRAMADE-HACIA DE VIAJES (Lote/semanal)												
	A	B	C	D	E	F	G	I	J	K	L	M	N
A		7	-	-	-	-	-	-	-	-	-	-	-
B	-		-	-	10	5	-	-	-	-	-	-	-
C	-	-		-	-	-	1	-	-	-	-	-	-
D	-	-	-		-	-	-	1	1	-	-	-	-
E	-	-	-	-		-	-	-	10	-	-	-	-
F	-	-	-	-	-		-	-	-	5	5	-	-
G	-	-	-	1	-	-		-	-	-	-	-	-
I	-	-	-	-	-	-	-		-	-	-	5	-
J	-	-	-	-	-	-	-	10		-	-	3	-
K	-	-	-	-	-	-	-	-	-		-	5	-
L	-	-	-	-	-	-	-	-	-	-		4	-
M	-	-	-	-	-	-	-	-	-	-	-		2
N	-	-	-	-	-	-	-	-	-	-	-	-	

The following Initial Schematic Diagram, records the sequence of departments through which material is transported, Fig 3.

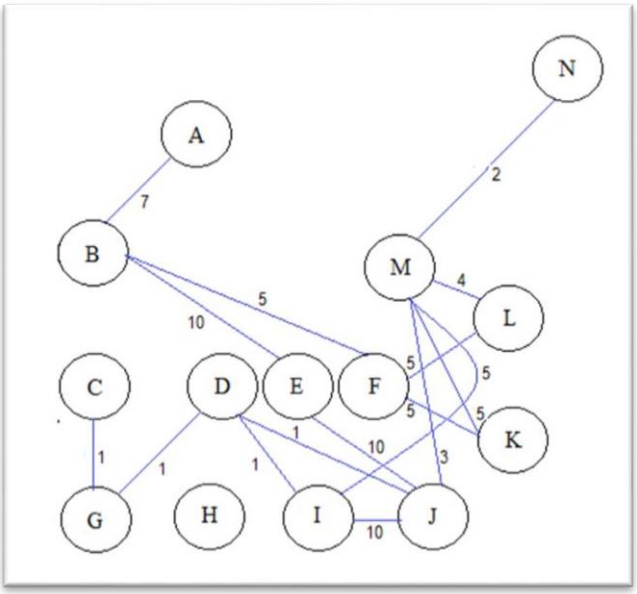

Fig. 3. Graph of current flow between departments showing the number of trips per day

When the process oriented layout is applied, the strategy is to place the departments or work areas in a way that minimizes the costs of transporting the material, bearing in mind that these generate one of the highest costs in the manufacturing process.

To better understand, departments with large flows of material between them, people or components should be placed together. The cost of material handling in this approach depends on: Konz, (2002).

- Number of loads or people to move between two departments during a period.
- Costs related to the distance between sections or departments.

To find the costs of material handling between departments, i.e. what it costs to transport material between departments, it is assumed that cost is a function of the distance between sections. The objective function Hillier and Lieberman (2010) can be expressed as follows:

$$minimize\ cost = \sum_{i=1}^{n} \sum_{j=1}^{n} Xij * Cij \qquad (1)$$

Where, n= number of workstations or sections
i, j = individual sections
Xyy= number of loads moved from section i to section j
Cij= cost of transporting a load between section i and section j.

Process-oriented facilities, as well as fixed-position organizations, seek to minimize the product of loads or displacement by distance-related costs. The term Cij combines distance and other

costs in a single factor. Thus, it is assumed that not only is the difficulty of transportation the same, but that the costs of collection and delivery are constant. Although they are not always constant, for simplicity data are taken as: cost, difficulty and costs of collection and delivery, in this only variable.

A problem in the flow of material is evident in the lack of mechanisms for transporting the material, this is done by operators in boxes, loading them manually. In order to find the cost per meter of the journeys, we based ourselves on the distances covered, which are shown in Fig. 1. We take the value of the salary of the collaborators, which is equivalent to Col$781,242 (LMVS), as a monthly basis, we work 8 hours a day, during 6 days a week, the average travel time per meter is 3 seconds. It is then established that the meter of the material has a cost of $3,3908 daily, 5 batches of 100 units of electrical controls of 40K a day are produced. These costs are recorded in T*able* 3.

Tab 3. Daily cost of travel of material between departments by lot (Col$)

	DIAGRAMADE-HACIA DE COSTO DE VIAJES POR LOTE SEMANAL (Pesos)												
	A	B	C	D	E	F	G	I	J	K	L	M	N
A		$ 522,52	-	-	-	-	-	-	-	-	-	-	-
B	-		-	-	$ 950,04	$ 508,95	-	-	-	-	-	-	-
C	-	-		-	-	-	$ 30,54	-	-	-	-	-	-
D	-	-	-		-	-	-	$ 47,50	$ 67,86	-	-	-	-
E	-	-	-	-		-	-	-	$ 746,46	-	-	-	-
F	-	-	-	-	-		-	-	-	$ 203,58	$ 203,58	-	-
G	-	-	-	$ 47,50	-	-		-	-	-	-	-	-
I	-	-	-	-	-	-	-		-	-	-	$ 305,37	-
J	-	-	-	-	-	-	-	271		-	-	$ 183,22	-
K	-	-	-	-	-	-	-	-	-		-	$ 237,51	-
L	-	-	-	-	-	-	-	-	-	-		$ 108,58	-
M	-	-	-	-	-	-	-	-	-	-	-		$ 814,32
N	-	-	-	-	-	-	-	-	-	-	-	-	

Therefore, the cost of transportation between departments is as follows: Cij = (distance between departments i - j)*(Cost of meter of material travel)*(number of journeys between departments i - j).

From the above, it is concluded that it costs the company $2,522.7552 per day per lot to transport the material between departments; that is, the movement of material has a cost of $302,730.624 per month to meet the production of 120 lots/month of 40K electrical controls in El Cebú LTDA. The annual cost for materials handling corresponds to $3.632.767,488, with the current layout.

Finally, using the error test method and with the help of the WQSB software, an attempt is made to improve the layout, in order to establish a reasonably good layout of the departments. Based on the flow chart, as well as on cost calculations, and taking into account that departments A and N, which correspond to the raw material warehouse and the finished product warehouse respectively, cannot be moved due to their infrastructure; it seems reasonable to bring department M closer to department N, as well as to try to bring departments E and J, and departments B and E, which handle a high volume of material movement between them, which causes a high handling cost.

Besides, it is taken into account that the floor areas, that is to say, where the material is left to be processed, are not fixed so they can be moved, taking into account the availability of the spaces. Below are the three alternatives thrown by the tool:

Proposal 1. The cost of material handling is $2.312,5256 * 5 lots * 24 days = $277.503,072 per month.

Proposal 2. The material handling cost of proposal 2 is $1,783.5608 per day per lot * 5 lots * 24 days = $214,027.296 per month, which corresponds to $2,568,327.552 per year.

As we can see, the best proposal is proposal 2, since it reduces material handling costs by $88,703,328 per month; that is, a total saving in material movement costs between departments of $1,064,439,936 per year, implementing this proposal in the company. To complement the decisions on the best location of the departments in the company El Cebú LTDA, improving the flow of material within the production process and minimizing the costs of transporting the material; the tool of Diagram of relation of activities is applied. From the activities diagram, it can be observed that the finished product warehouse is on the second floor, which generates very long displacements on the part of the collaborators, with product loads, by stairs.

Finally, in Fig 4, with AutoCAD software design, the proposal for the redistribution of departments or work areas is presented, as well as the flow of material that follows the process for the manufacture of 40 K electrical controls. Which will be implemented by management immediately.

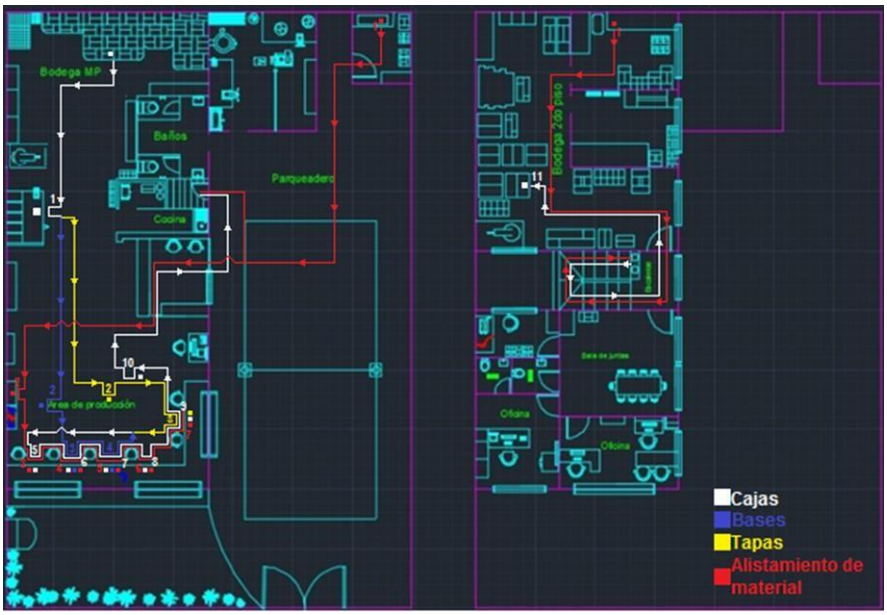

Fig 4. Proposed layout for Cercas El Cebú LTDA.

CONCLUSION

It is estimated that more than 20% to 50% of total operating expenses incurred within the manufacturing area can be attributed to plant disposition, an efficient distribution probably reduces those costs by a value between 10 to 30%.

At the El Cebú LTDA production plant, material handling costs currently amount to $3,632,767.488 per year with the current layout, for the manufacture of 40K electrical controls with a production of 12,000 units per month.

With the relocation of the proposal 2 workstations for El Cebú LTDA, material handling costs are reduced by 29.3% per year. The company's savings on these costs are $1,064,439.936 per year.

It is necessary to implement a mechanism for the transportation of the material, since the storage of both raw material and finished product are on the second floor, and it is not recommended to lower them, due to the current infrastructure of the building. The most convenient and economical proposal to attack this problem of material flow is a mechanical elevator that supports the production lots. When technological modifications are made, it must be evaluated the performance of the transport systems in the plant or other different parameters according to the nature of the modification.

Based on the proposal presented in this project, for the redesign of the plant, a flexible design is proposed in the facilities that allows adapting quickly to changes in demand, in the introduction of new products, without harming the production levels currently demanded.

The proposal presented for redesign as an improvement of the production process, apart from reducing material handling costs; it is guaranteeing a workplace with fluid circulation of people and materials; without reprocessing, avoiding as much as possible, the crossing in the flow of material, eliminating unnecessary costs and delays in production, waiting and so on.

Through the use of the software, it was possible to deduce, from the quantitative analysis, the visualization of improvements when approaching the workstations. It seems reasonable to bring department M closer to department N, as well as trying to bring departments E and J, and departments B and E, which handle a high volume of material movement between them, which causes the highest costs of handling and transporting material in the process.

It is important to maintain a balance between plant transportation and process capacity, as well as the interaction between these two variables; since they directly impact the performance of the company's plant distribution.

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