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Layout as a Determinant Factor in the Efficiency of Industrial Manufacturing

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***Abstract*— In face of the pressures exerted by the globalization of the markets and the needs to meet the expectations of consumers, companies seek to improve their organizations at different levels. To meet these requirements and survive in increasingly dynamic scenarios, companies must be aware that they can not to be more static and they must adapt to gain competitive strength.**

In this context, the study of the industrial layout assumes an important role integrating all the elements involved in the production process. The rational use of available physical resources, a demand for operator safety, products and equipment, greater flexibility in the production process and ease of production management are inherent objectives of the industrial layout, which companies will inevitably have to pay more attention. Thus, this article intends to demonstrate the relevance of the thematic study on the layout, as well as the vital importance of the restructuring of organizations in the face of constant adversity and challenges that they are subject. To this objective, we present a case study layout of a manufacturing wood-based, with a proposal for improvement based on the SLP (Systematic Layout Planning) method, combined with practical considerations and constraints, discussed here, and presents in industrial facilities.

***Index Terms*— efficiency, layout, productivity.**

I. Introduction

Due to rapid changes in production techniques and the emergence of new equipment, few companies are able to maintain their facilities with the same layout without prejudice to its competitive position. One of effective ways to increase productivity and reduce costs is to eliminate or reduce excess activities that don't add value. This includes monitoring equipment and personnel, the need for increased quality, reduced inventory, improved production process, improving safety and health of employees and efficient use of energy resources. All these activities are performed through the modification/adjustment of the layout of existing facilities, or re-layout. Planning an effective facility layout enable the manufacture of the products in the required volume and variety and can significantly reduce the operational costs of the company amounting to 10-30% [1]. Reference [2] argues to the layout of facilities as an optimization problem that tends to create more efficient arrangements taking into account various interactions between facilities and material handling systems. The reduction in material handling would lower WIP, lead time and reduces the likelihood of defective products. In addition to the needs of product movement, access and support services for the production and the employees that operate in the factory should be foreseen [3]. It is also important to obey the demands of operations so that people, materials and equipment move in a continuous flow, organized and according to the logical sequence of the production process. In this sense, should be avoided crossings and returns, as well as unwanted obstacles and minimize transportation distances. The space should be used as best as possible, seeking to optimize efficiently all three dimensions: length, width and height. Since satisfaction and worker safety are very important, planning and implementation of the layout should look to the human factor with regard to the welfare of operators, as well as the decreased risk of accidents. Beyond the factors above-mentioned, the layout must be flexible. In recent years, with the markets becoming increasingly dynamics, are required rapid changing of the products, methods and systems of work. It should also be noted that facilities that operated in volatile environments, or need to introduce new products on the market regularly, sometimes can not bear the costs of stopping or re-layout, in part by the rigidity of its production processes, so in these cases, often prefer to live with the inefficiencies of existing layouts and not suffer the costs of change, which can quickly become obsolete again [4]. Thus, the aim of the study was to optimize facilities to minimize the cost of transportation of materials between them. To this objective, we present a case study layout of a manufacturing wood-based, with a proposal for improvement based on the SLP (Systematic Layout Planning) method [5], combined with practical considerations and constraints, discussed here, and presents in industrial facilities. Based on the scheduling and production volume variability of products and processes, [6] define the main objectives for the study of layout and optimization of space available in production facilities, which will be considered in this study: i) minimize the total production time; ii) maximize use of space; iii) maximize

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safety and comfort of the operators; iv) enhancing flexibility in the provision of equipment and operations; v) minimize the cost of material handling; vi) to minimize variation in the types of equipment and materials handling; vii) optimize the production process; viii) optimize the structure organizational; ix) minimize investment in equipment; x) promote the flow of information and operational management.

II. Applied method

Traditionally, the project layout is distinguished between two approaches, the first refers to a quantitative approach, to minimize the total cost of handling the material flow between departments of a production installation, the second refers to a qualitative approach that seeks to maximize the proximity of the various departments of a facility. Within this, a systematic approach that is often used is the SLP. The SLP method applied to optimize the layout of existing machines [7]. The application is expected to make the fastest material flow with the lowest cost and least amount of material handling [8].

A. Steps to implement the SLP method

The preparation of the draft layout is developed by the analysis and decision given five different levels, namely: global network, location area, specific location, layout construction and sectoral or departmental workstations layout. In order to study the subject in question, it must focus the attentions on the fourth and fifth level. Reference [9] states that the method of systematic layout planning is divided into three steps, called analysis, research and selection, as represented in Fig. 1.

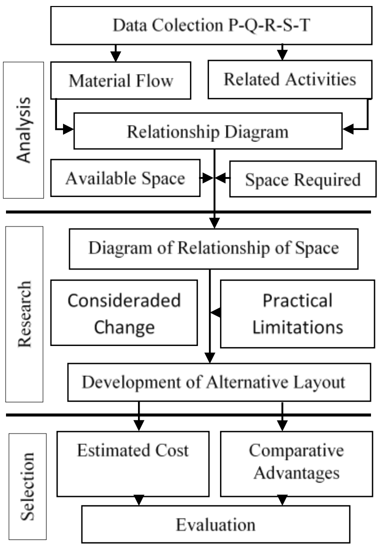

Fig. 1. Structure of SLP method [9].

B. Analysis

Data Collection

The analysis stage begins with the identification and collection of data in the production process, both quantitative and qualitative, initially represented by P (product), Q (quantity), R (route), S (support) and T(time), where:

- P (product) is what is produced by the company, may be considered the full range of products processed at the site;
- Q (quantity) represents the volume of the product material produced or supplied or used, may be expressed as unit form, weight, volume, etc.;
- R (route) represents the process followed in the factory, according to which the product or material is produced;
- S (support) represents all activities or functions that assist the production process, providing the actual operating conditions, such as machinery, tools, materials handling equipment's, departments, etc.);
- T (time) represents the timeline set for the end of a project or action. The execution times will tell us how many resources will be needed to achieve the objective, namely, equipment, space, manpower, among others. Since the execution time of an action or delivery is part of the measure of time, shown the pace of production and the responses of support services.

Due to the quantity and variety of models produced, we will direct the present study for the models more representative and more complex.

The type of production process adopted, is the process by order. In this type of production process, the production planning is based on the organization of orders by type of product to be manufactured. As resulting the production order is a productive flow directed as a response of the orders. This type of custom production, is non-repetitive nature and the quantities and products can vary greatly. Thus, each application usually involves a variety of operations. Considering the variation of quantities produced in each order, variety and range of products that the company delivers to the market, we believe that the type production by order is the most fit to ensure the effectiveness and efficiency of their productive activity. Due the flow of products and information flow by the process according to the needs, this type of layout is very useful to obtain flexible streams of various types of products.

Material Flow and Related Activities

The materials flow consists in determining the best sequence, the best intensity of material motion, considering the production steps. To this end, the method is used to represents the flow between the different departments, and related activities analyzed quantitatively in pairs, in order to decide the need for proximity among them [10]. The flow should allow the material to move in a progressive manner during the process, no returns, diversions, crossings, etc. This is a way to know the volume of material transported between departments and the frequency of this movement. For analysis of material flow is commonly used a flowchart of the processes [5].

The related activities represent the interconnection of support services to each area of the production department, establishing the closeness between them. The diagram of interconnections most utilized is a triangular matrix which represents the degree of proximity and their ratio between a

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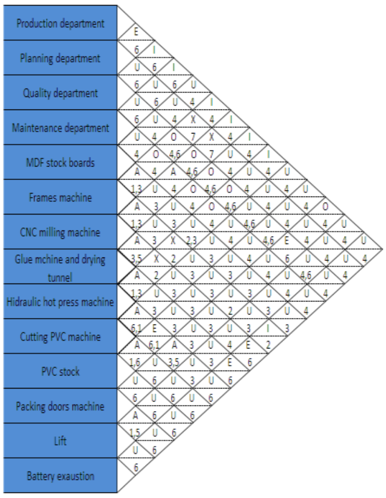
pair of activity / departments in the production process. The construction of the diagram of activities related requires the identification of reason and the weight of importance of proximity or remoteness. Thus, habitually is utilized the letters "A, E, I, O, U and X" [5], to identify the reason of proximity between departments that will be classified. Thus, through a combination of reason with for the closeness we obtain the diagram of interconnections preferred, Fig 2.



Value	Reason	Nº	symbol
A	Absolutely necessary	9	
E	Very important	5	
I	Important	7	
O	Normal proximity	8	
U	Unimportante	58	non
X	Undesirable	4	
TOTAL	$\frac{\text{Nº Dep. X (Nº Dep. - 1)}}{2}$	91	

Code	Reason
1	Common labor
2	Contamination by dust
3	Process flow
4	Participation in the process
5	Handling machine in common
6	Direct interaction
7	Noise

Fig. 2. Diagram of interconnections preferred.

The objective is to evaluate which activities should remain close and which will be removed within the production flow.

Relationship Diagram

At this stage, the production departments and support services should be linked via a relationship diagram. To prepare this diagram, is used the symbolism of each action, with the reason of closeness resulting in a preferential interconnection diagram. The purpose of this diagram is to find an array of layout, where the distances between the various activities/departments with the highest interaction are as adjacent as possible. We represent in Fig. 3 one example of a relationship diagram observed in the study case.

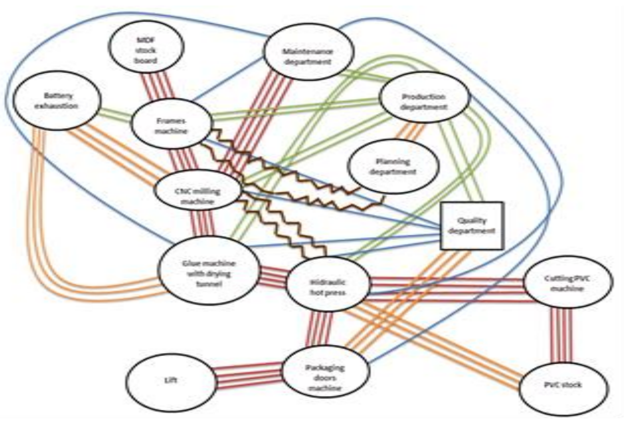


Fig. 3. Preferential interconnection diagram.

Space Required and Available Space

To complete the analysis phase is necessary to consider the space required and available. This step is accomplished through the analysis of machines and support services involved in the production process. Taking into account the installation area, we consider one space available for its production process. It is assumed that the company has no surrounding space for a possible expansion of its building, which adds responsibility in the management and profitability of existing space for the arrangement of its constituents. This way, it should try to minimize idle areas, which can lead to the idea of missing space for future investments in the current installation of the company. Therefore, the decision about the space required in an industrial installation, is perhaps one of the most vulnerable and unpredictable steps in the project layout, as its relying on external factors that may difficult to predict, as e.g., technology, product mix, demand, etc.

In this study, we consider the need for space at the facility, including the need of flexibility of the layout for future reformulations of the project.

This phase is particularly useful in developing projects, so, it is important raise awareness players to the importance for utilizing the available space.

The areas shown in Fig. 4, correspond to the minimum areas for each service of the installation in the case study analyzed.

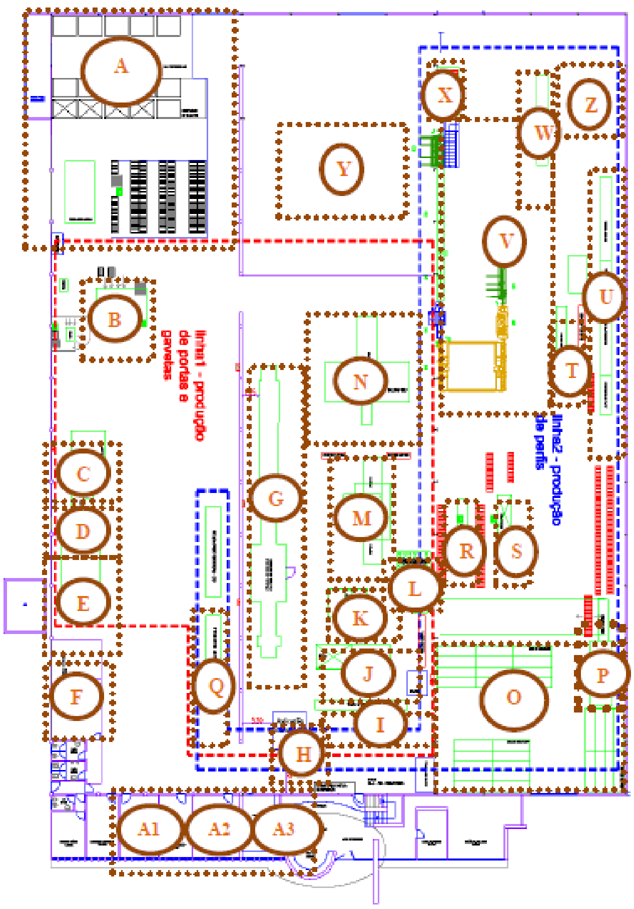


Fig. 4. Support services area.

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C. Research

Diagram of relationship of space

The research phase begins with the preparation of the space relationship diagram, which is characterized by a balance between the space required and available. This step is intended to represent the presence of empty spaces within the areas of the installation.

Restrictions, change considerations and practical limitations

Considering the data collected and analyzed until this phase, the layout developed at should be set, considering the needs of the production flow and some practical constraints of the initial layout, that may hinder their full implementation, such as: i) the irregular flow of production lines, with advances and setbacks in the process; ii) high waste of time in transporting materials; iii) complicated handling material, which may lead to rejection; iv) delays in delivery of material in the subsequent process; v) unproductivity of operators, due the expectation of material for proceedings; vi) empty spaces; vii) location of production and quality departments, does not favor the supervision process; viii) lack of motivation and dissatisfaction of traders, resulting from the excessive distance between equipments; ix) provision of equipment in the line profiles, favors the undesirable increase in stock WIP and loss of productivity of machines and operators. Another constraint that must be considered in the development of a proposed layout is the financial viability of the project, in which the cost must be weighted with the expected economic return of the investment.

Development of alternative layout

Based on the necessary changes to the design layout, can be in the presence of more than one candidate layout, and it is therefore necessary to perform a weighting advantages and disadvantages relating to costs and factors involved unattainable each of the that will determine the choice of layout [9]. As example in this phase, we can highlight two different alternatives shown in Fig 5.

D. Selection

In the selection phase, an assessment should be undertaken of the various layouts candidates in order to determine which alternative or combination of alternatives will be chosen for installation. In this phase, some criteria must be established to determine the best alternative proposal. We can evaluate alternatives considering view of the distance along the production processes and the respective times spent distance between each stage of production. With results from the analysis of the data it is possible conclude if the alternative layout presents the best solution, greatly reducing the time spent on material handling, as well as the distance between devices in the process. The best alternative will be more advantageous, favoring the production flow and by promoting better linearity of the process. As consequence of reduced handling of WIP, is estimated reduction of wastes during the production flows. At this stage, it appears important to involve the largest possible number of workers in the decision, both, people who approve the layout, as well the respective operators of the process, in order to guarantee the successful implementation of the project [11].

Estimated costs with alternative proposals

This factor is particularly important in decision making by better alternative, since it can disable the acceptance of the best layout by the weighting factor of the cost-effectiveness of the new project.

It is possible calculate the costs involved in the propose changes, according to an estimate.

Comparative advantages and disadvantages

In this phase of the project it is possible compare alternative scenarios to describe the advantages and disadvantages with a systematic analysis, making the decision on which projects are best suited to current and projected needs for the future of the company.

Evaluation

Considering the production cycle times, and given the production capacity with the layout, at this stage, we are interested in calculating the estimated increase in production capacity, for each proposed alternative.

In this step, the analysis allows conclude with regard to increased productivity, what is best alternative. According to [12], before implementation of the layout or re-layout, it is important to note that in organizations there are cycles of expansion and retraction in the business, so the layout should be designed and implemented on a dynamic and flexible prospective in order to meet quickly and cost fluctuations within the production cycle.

III. Validation of Methodology

To demonstrate the advantages of the use of the concepts discussed in this article, we applied the SLP method in a real environment. The success of its application validates our methodology.

The company used as object of study, has its production facilities in Portugal, and dedicates its activity in the production of doors in MDF coated with PVC and profiles in MDF and plywood, PVC and coated veneer. The company has several distribution warehouses in mainland of Portugal and in Madeira island and reflects 70% of its production to exports. The production process is distinguished by two production lines, 1 and 2, representing the current layout of the installation.

In order to respond quickly to new demands imposed by customers and competitors and increase its competitiveness, this company needs to become more flexible. Thus, the goal of the study was to demonstrate the influence of implementation a layout structured approach in efficiency of the production. After the application of the methodology it was identified good opportunities to improve the production, which has illustrated the effectiveness of the proposed method. This way, it was possible achieve the

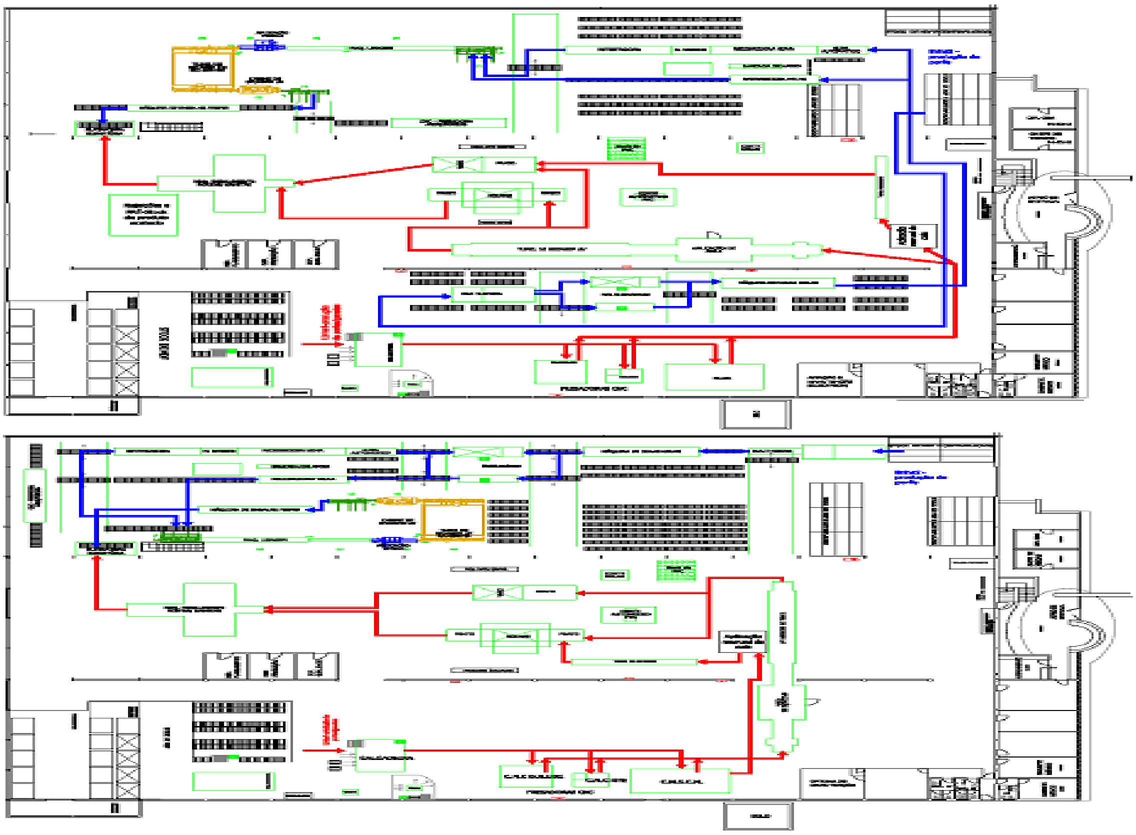

Fig. 5. Alternatives 1 and 2 for layout project.

objectives of company in the organization of the production process, as well to reduce of production costs, which helped strengthen its position in national and international markets.

Due to be impossible in this paper to present all work developed, so only a brief description of the results and the conclusion will be presented.

IV. RESULTS AND DISCUSSION

According to the results, two alternative layouts were suggested by SLP. Taking into account weighting factors, production cycle time, production capacity estimated cost of design change and comparative advantages and disadvantages, it was possible to choose the most advantage layout. The results revealed that the second alternative project to re-layout of the site stands out preferably on first alternative, (see Fig. 5). The main considerations that can be mentioned are: increased the proximity of facilities, linearity of the production process, reduction of unproductive times that do not translate into added value, increased productivity, employee satisfaction and industry flexibility. Moreover, the decision to choose the layout proposed in alternative 2, is considered the most fits the needs and expectations for the current and future of the company. Although the alternative selected has one main disadvantage, with regard to costs of re-layout, due the estimated increase in production capacity, it is considered that its depreciation can be achieved in the short/medium term.

Through the analysis of the results, it is possible to verify if the new layout is a best solution when compared to the initial layout. The decision-making is based on different factors, like the estimated increase in production capacity, with an expected increase of company's competitiveness in domestic and foreign markets.

It seems also important to consider the point of views of the employees. The presentation the new layout project was accepted with enthusiasm and motivation by workers of the company. The greater proximity of equipment and linearity in production processes, it will allow to reduce the physical effort required in the operations involved.

V. CONCLUSION

This article, through the concepts studied in the literature review and the case study using the SLP method, intended to demonstrate the importance of the project layout and re-layout and its contribution to achieving competitive results in the companies. This way, it is expected to contribute in a practical way for the efficiency of the production process, not only through increased competitiveness, but also through the awareness of all labor people to the importance of organization and orientation of room for improvement flow in the production process.

The considerations taken in preparing this study, in accordance with the objectives established, were: i) to minimize lead time process, particularly with the reduction of time devoted to the transport of materials, allowing faster production process; ii) maximize use of available space, with the reduction of empty spaces, which increase the proximity of the equipment within the production processes, reducing operating costs from such use; iii) maximize safety, satisfaction and comfort of the workers, proving to

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be a factor extremely important for increasing productivity; iv) enhance flexibility in the provision of equipment and operations, as a consequence of linearity and proximity between workstations, optimizing the production process and organizational structure; v) minimize investments in equipment and means of support process; vi) promote the flow of information and operational management to promote a more dynamic and flexible process capable of responding to changes in demand and variability of products; vii) to promote flexibility of equipment as a way to maximize returns on them; viii) minimize costs of re-layout, which could compromise the viability of the project. As a result of the application of this study in a practical case it was possible reduce time and costs of transporting material in 37%, to line 1 and 62%, to line 2. Regarding forecast increase of production capacity, it appears that is direct result of reduced time spent material handling, with the principle that all conditions are met for this purpose. However, it appears that there are constraints on the current layout that were not taken into account for the inability of current and which can be quantified in the practical application of the draft and contribute to increasing the production capacity provided, such as: i) considered that there is no waiting time for lack of availability of material handling, ii) considered that the distance traveled by material handling there is traffic congestion in the intersection of materials between processes; iii) considered that the resources human common to several devices are available in every step of the process when necessary (resulting from the distance between devices).

In resume, it is expected that the installation of a more efficiently project layout, positively encourage the organization so that it can achieve the goals outlined and gain competitive advantages over its competitors, increasing its market share.

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