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**Increasing the Productivity by the Change of Layout and by the Improvement on the Work Stations – A Case Study**

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*Abstract: Competitiveness on the automotive sector presses auto parts suppliers to be more agile on the manufacturing and assembling of parts. Moreover, they are expected to present low costs of production (and low prices of the products), good quality (according to the established by their costumers), high productivity and flexibility, among other requirements. In the search for techniques to reach these requirements, auto part suppliers are working on the layout to optimize and improve their results. Layout is an important component of the manufacturing systems, once the functional organization of layout can arise a lot of benefits to the manufacturing system. This issue analyses the process of layout change that was conducted in an auto part supplier located at Campinas – SP - Brazil, that produces fuel pumps. The change of layout included requirements like the way that milk run occurs, people ergonomics and products flow, and resulted in a reduction of lead time of production, increase of the production capacity, in the reduction of area occupied, among others significant results.*

*Keywords: Layout; Optimization; Productivity.*

## Introduction

The search for competitive advantages, particularly in the automotive sector, has led Companies to seek production methods that improve the performance of their manufacturing systems in general. Since the 50's, Companies, who have been working with the methods that have revolutionized the production processes of the automotive sector inserted by Taylor and Ford in the early twentieth century, have undergone major changes because the high volumes of stock, parts flows poorly designed, poor quality, delays in production, which inter alia represented the reality of production, are factors that reduces the competitiveness of enterprises.

According to Slack (1995), companies must have five targets to stay and be more competitive in the market, namely: Quality, Cost, Flexibility, Productivity and Speed; these targets are important in a globalized market. In this scenario, stands out even more the need for mechanisms that seek greater efficiency and lower costs in production processes, not only to reduce this, but for the survival of any company.

Some companies have turned their focus to layout optimization techniques, which are increasingly being employed in the manufacturing process in order to adjust the

processes efficiently and rationally. One way to reduce these problems is to define the layout to fit properly to the type of production system; thus, one should make a careful study of form and layout and location of equipments (BAYAKASOGLU & GÖÇKEN, 2008).

Fiedler (2009) states that the study of the layout is of fundamental importance to ensure a clear rapport and an internal harmonious functioning of the environment. This same author also reinforces the idea that a work prepared optimally ensures the aesthetics of the site and a rational flow of the process.

According to Tompkins et al (1996) apud Rentes et al (2007), some significant changes are occurring in the manufacturing system, motivated by the following trends:

- Increased number and variety of products, resulting in a decrease in quantity (the lot size) as diversity increases;
- Cost of materials, including handling of materials and energy, the main part of the total cost of products;
- Need to reduce design time and manufacturing of the product due to changing market; a product can become obsolete even before it is produced;
- Increased requests for smaller tolerances (more accuracy and precision to produce higher quality).

With all these changes in the consumer market, Lee (2001) suggests that manufacturing is supposed to: focus their strategies on the flexibility to handle a wide range of products, have small lots and working with a reconfigurable manufacturing system, in order to obtain a quick answer system aiming at better use of resources (especially the more expensive), and a design to meet as soon as possible to the demands of various customers.

The customization of production is also a key strategy for some companies, as some differentiated products tend to have a good acceptance of the consumer market. The main goal of personalization is to make products that meet specifications imposed by the client, compatible with the prices of products produced in large scale and thus the company reaches a differential on its portfolio (TORTORELLA & FOGLIATO, 2008). The purpose of this paper is to present a layout change occurred in a multinational company in the inner of São Paulo State - Brazil, comparing the former results with those obtained after these changes. The methodology used is the Case Study, with a brief theoretical background about the types of layout.

## 2. Layout

The layout of a production system is an important point to get good results in the production and to serve the clients within the time specified in the contract, and with costs competitive to the market. To Rentes et al. (2007), a proper design of the layout implies a reduction of movement of both operators, such as parts and products. Canen and Williamson (1998) point out that the production resources are of vital importance for the company because, in most cases, are certainly their biggest and most expensive asset, and the main reason for planning the layout of the productive sector is an interest in reduce handling costs and unproductive time.

There are different types of physical arrangements in the manufacturing system, Black (1998) proposed five projects for manufacturing systems that can be identified as: functional layout (job shop), production line layout (flow shop), fixed position layout (project shop), interconnected manufacturing cells (cellular layout) and continuous flow layout, the latter most commonly used for processes that use liquids, powders and gases

(continuous processes) rather than parts that make a product for example (intermittent processes).

The functional layout (job shop) is characterized by a kind of physical arrangement in which all processes and equipment of the same type are positioned in the same area. Rentes et al (2007) points out that the physical arrangement of the process provides a flexible production system to adapt to various products, and that this organization requires machines cost less than a physical arrangement for such product.

Martins and Laugeni (1998), apud Rentes et al (2007), defined the continuous flow layout as the machines being placed according to the sequence of operations that are performed. There is not a different way of manufacturing because materials run into a predetermined track within the manufacturing process. For the continuous flow layout, Black (1998) mention the example of a transfer line producing an engine block, where the lines produce large batches; any change to make another similar component can take hours or even days to accomplish.

For the fixed position layout (project shop), Slack et al (1995) says that the physical positional arrangement is somewhat a contradiction in terms, since the resources processed do not move resources between processors, but it just happens contrary: these processes are characterized by the immobility of the items in manufacturing. In the fixed position layout, machines, workers go towards to work. As an example of this item, we can mention bridges and highways in the area of construction; already in manufacturing, we have ships, locomotives and planes as an example.

The layout of interconnected manufacturing cells, or as it is known, cellular manufacturing, layout is composed of islands of production where the physical organization is assigned to a set of products that undergo specific operations. The formation of cells, according to Conceição (2005), is one of the main events in the design of a cellular manufacturing system. It involves the grouping of parts into families and grouping machines into manufacturing cells, according to the very well known Group Technology (GT). In this case, it is clear the intention to obtain independent manufacturing cells, ie, no part must be processed in more than one cell; if it occurs, it generates a stream of intercellular exception.

In the last layout type, called continuous flow, the product flows physically through the production line. This process is considered one of the most efficient, but is the least flexible of all the manufacturing systems. It follows a configuration given by the sequence of processes, and it is the easier to be controlled. However, changes are particularly difficult to be implemented.

### 3. Case Study

The project and the process of changing the layout were performed in a large company located in the State of Sao Paulo - Brazil. This company focuses on the automotive industry, and is a leader in the manufacture of fuel pumps for cars and flex fuel (ethanol and gasoline), with an average production of three million units per year. The company currently serves both the domestic market, as the external, extending its production to also levy and sets for motorcycles.

Initially, it was investigated the initial layout in order to visualize the defects contained therein, and to identify issues to correct them. In this step, it was identified that the layout did not have a well-defined production flow, creating counter-flows. It was also found an excessive movement of the operators, including rotations of the operators trunk in 90 ° and 180 °, which contradicts some principles of ergonomics in the workplace.

Figure 1 shows as were the production lines L1A and L2A before the changes. It may be noted that the red line represents the flow of parts in the assembly; this proves to be ill-defined, because there are crossovers and uncertainties about the path being followed.

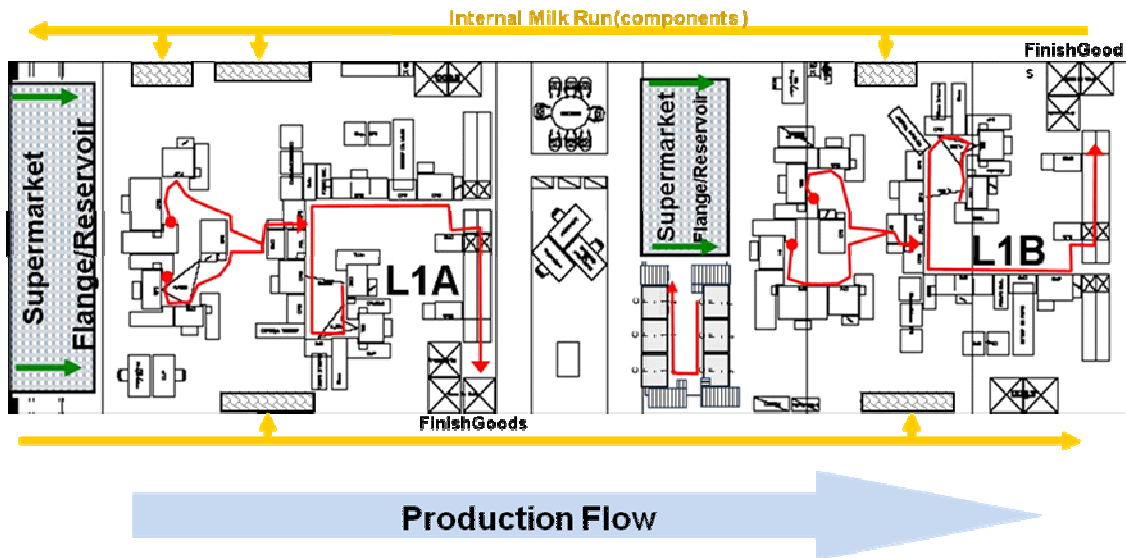


Figure 1: Schematic layout prior to the changes.

In this layout there was great difficulty in getting supplies of materials from the warehouse, from outside suppliers, such as tags, washers, springs, filters, clamps, etc. Other shortcomings were the counter-flow of material, discontinuous flow, and problems with ergonomics for operators and excessive movement of the operators. This was taken as the basis for the analysis of the future layout, trying to correct these flaws. Since then, the company outlined some goals for deploying the new layout, which were improving the production flow, bring the case to the concept Toyota Production System (TPS), to improve the supply of components on the assembly line, reducing the manufacturing time to increase the productive capacity of the system, ergonomics of the operators, optimize the layout to reduce the area and to decrease the fixed asset. After outlining the company's goals, were established six goals for this system to be deployed. These goals were: Level of efficiency, ergonomics, flow components, footprint reduction, reduced cycle time and reduction of fixed assets of the company. Was created, then the first draft layout, reducing an area the size of 200m<sup>2</sup>, but the proposal was rejected because it generated a corridor that cuts through layout, which was not appropriate (Figure 2).

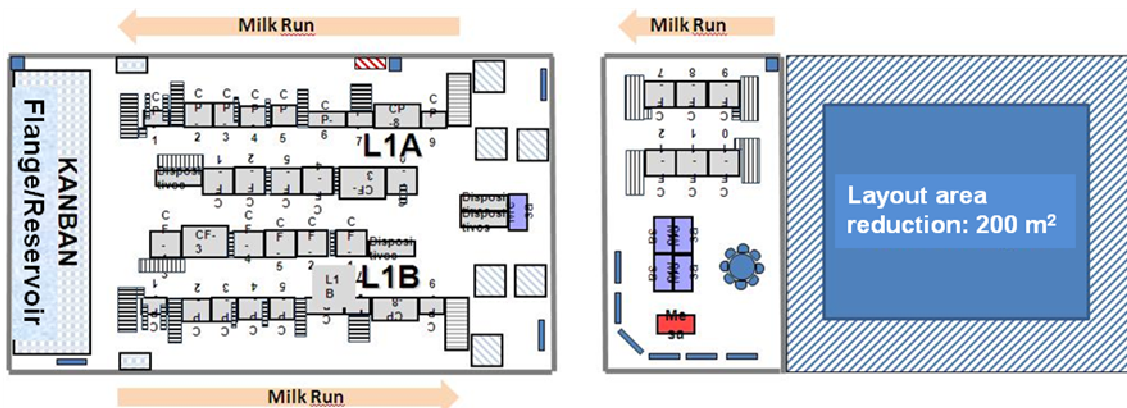


Figure 2: First draft layout rejected.

A second layout option was proposed, but also being rejected. In this option was eliminated the first corridor that had been proposed, but were still difficulties for the supply of components on the line, as this was proposed in an indoor corridor between the two production lines (Figure 3).

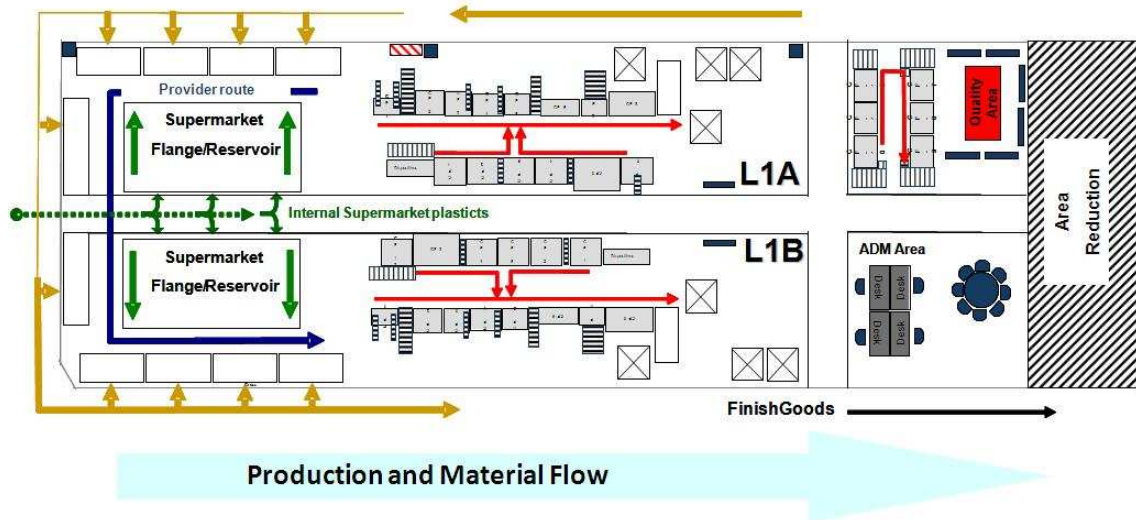


Figure 3: Second draft layout rejected.

However, from this second draft appeared that which was adopted: a simple reversal of the supply of components, not by an internal corridor, but by the corridors outside, where normally there is already traffic of people and trucks, making this supply without any need to go into the midst of production. The proposal also brought a reduction of 20% of the total, which is, in present value terms, the amount of almost \$ 100,000.00 (hundred thousand dollars) per month to reduce fixed cost for the company. The flow was well defined and organized, minimizing excessive displacement of the operators through the system of production. In figure 4, it can be noted that the new arrangement of the physical layout facilitates the flow of production, and also that the area had been reduced, not interfere with the layout of the new arrangement, which ended up increasing its production capacity.

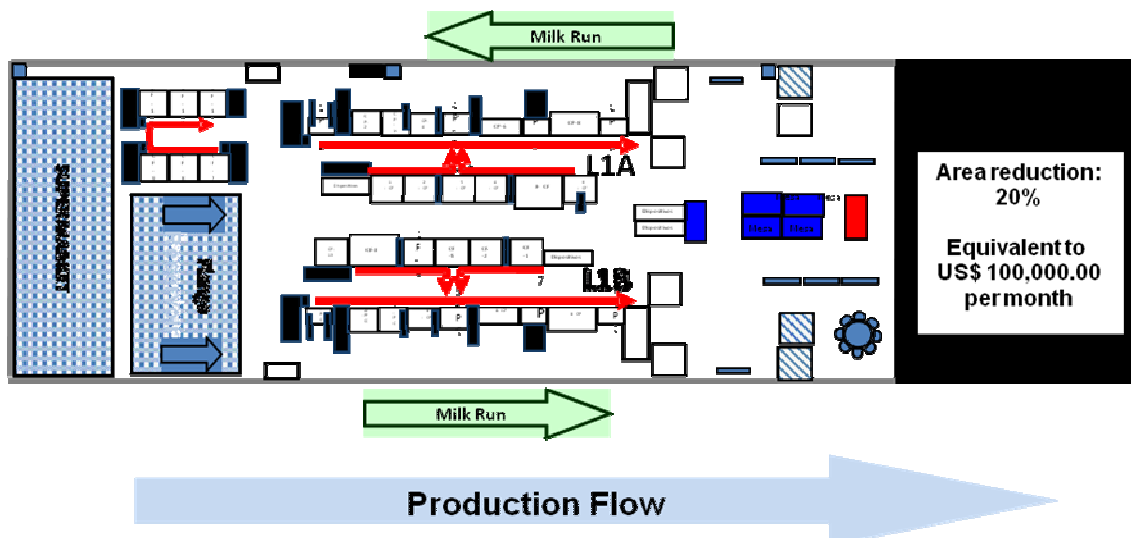


Figure 4: New physical arrangement of the layout.

### 3.1 Other improvements

In this optimization of the layout, some other improvements were incorporated in the workplace with the intention of reducing both the physical space such as the production time. In a specific site for testing and assembly, which was done in three steps in three different quarters, with a total of 2090 mm, it presents now a single station with the capacity to perform the three operations at the same time, with only 60 mm size, reducing this phase of the process in floor space and time (changes in the workplace have been eliminated and there is only one operation of loading and unloading of parts). Figure 5 illustrates the job before the revision, and shows the three stages of this process.

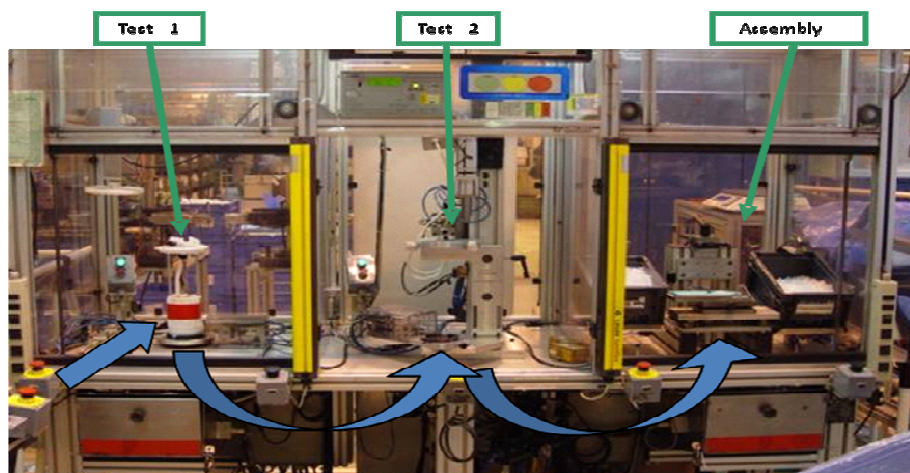


Figure 5: Photo of the job before the makeover.

Figure 6 shows how got the job after the revision, that besides the small size of the stand, also eliminated the excessive movement of the operator, saving time and space.



Figure 6: Photo of the job after the makeover.

Another improvement that was implemented to reduce the setup carts, which were used to press a particular type of tube in a flange. This operation requires a cart specific for each product, or rather, for each customer. There was a total of nine setup carts, requiring long downtime of the production line so that they make the change. It was proposed the reduction of these setup carts, eliminating six of the nine existing carts. With all this change in the production process, the company's follow-up was during a period between July 2007 and March 2009. In Figure 7, are related the changes in demand with production capacity of the system before and after the changes (the year of 2009 is a forecast). It is observed that the production capacity increased and decreased cycle time in the new production system.

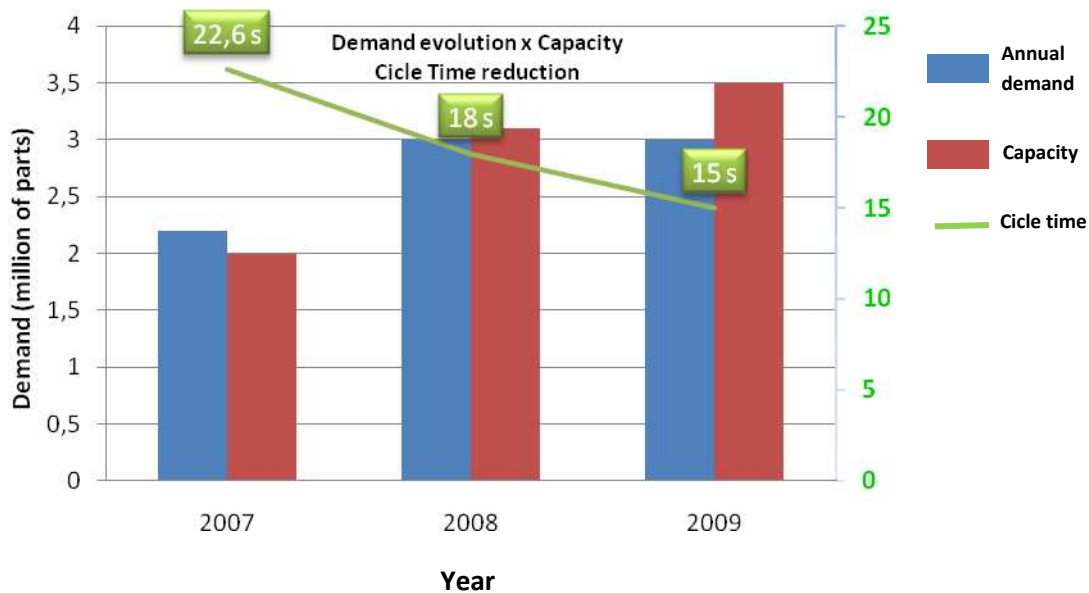


Figure 7: Evolution of demand versus capacity and reduced production cycle time.

Reducing the cycle time of 22.6 s, at first for 18s, falling more 3s in the third year, is due to the alignment of production and the adjustment of operators for new jobs. In Figure 7, we could observe that in 2007 the demand was greater than the productive capacity of the system, causing delays in deliveries to customers, following changes in the layout; production capacity is again greater than the demand. The goal "level of efficiency", which can be understood as the productivity of the system, was established in 85% and was achieved in 2009 as shown in Figure 8.

Another goal outlined by the company regards to ergonomics of workers. In figure 9 it is noted that there was a reduction in sick leaves by back problems. Another item found was absenteeism, which also had its rate reduced from five cases in 2007 to about 1 case in 2009.

For the flow of components, also defined as a goal the company, it was adopted the pattern of flow from TPS, that defined the size of lots in multiples of eighty or divisors of forty units.

The changes also adopted the system of two boxes, called "FIFO," which means "first in, first out", ie, the first coming in, is the first out. Another important fact is that was adopted to reduce the raw material for production, maintaining a minimum inventory for two hours of production only.

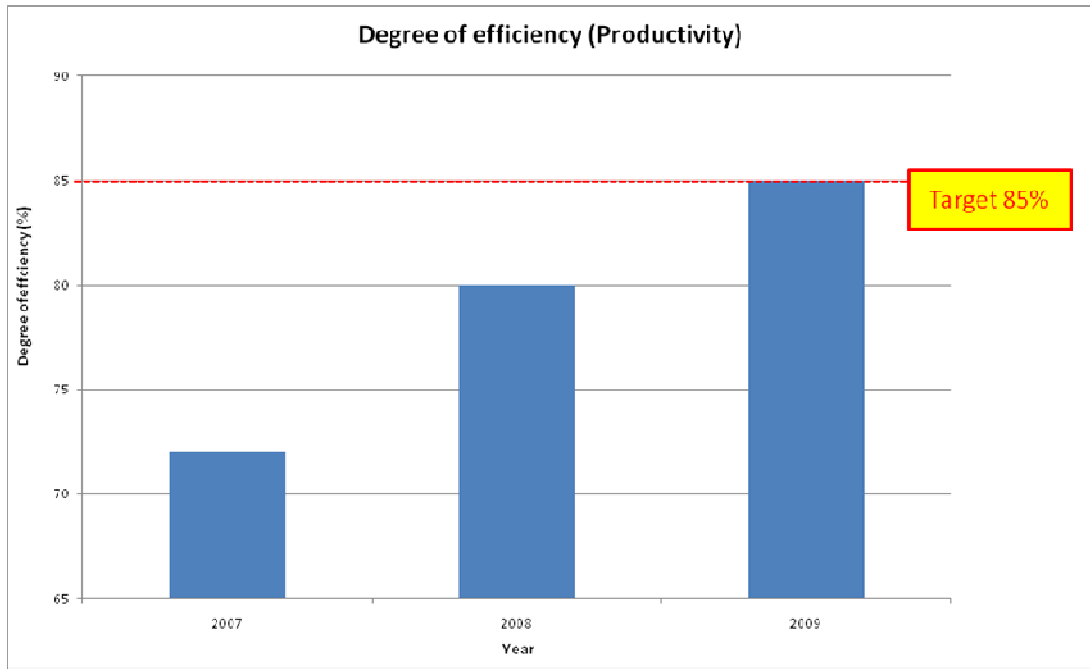


Figure 8: Degree of efficiency established a target 85%

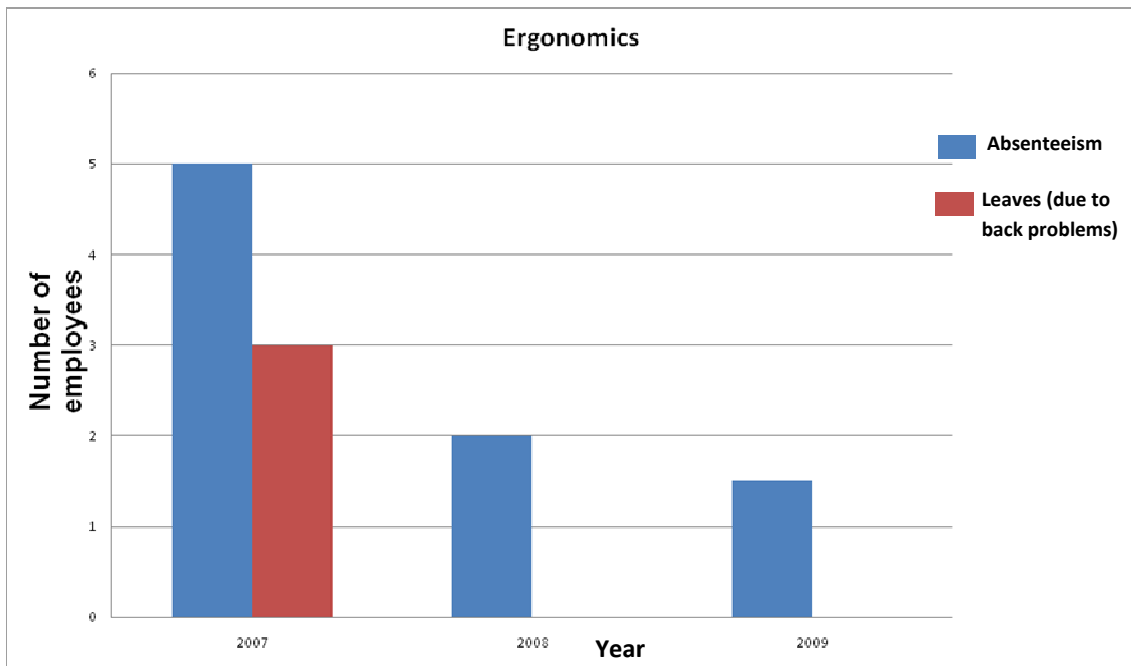


Figure 9: Results due to the changes on Ergonomics.

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In reduction target area, the gain was 20% of the total area used, reducing the cost of the production system in an expressive value. 1500m<sup>2</sup> total area was reduced to 1200 m<sup>2</sup>, and yet, increasing the productive capacity of the system manufacturing company. An important fact to remember is that the number of employees eventually reduced because some jobs decreased operating on the assembly line: a total of sixty-six employees were reduced to forty-eight. The lead time is also an important factor to be remembered; that before were 250 seconds and reached 162 seconds after the changes in layout.

#### 4. Final remarks

The layout has direct impacts on various sectors of the company, reaching from stocks to levels of productivity. To design and to make changes to the layout in order to eliminate waste, and excessive movements of the operators, reducing the area used and optimize the process flow, improving the ergonomics of the operators, are critical, among others, for the process of improvement that many companies aim.

The Toyota Production System, used as a foundation for all these changes, is a vital tool for the survival of many companies, once this system aims at reducing any waste that exists in the shop-floor. The companies are been forced to continually optimize their manufacturing systems, eliminating waste in the system and increasing its production capacity in order to reduce its cost. They must be prepared for the competitive market.

Changing the layout can be considered an important factor for continuous improvement in pursuit of the ideal production system without waste, with low cost, high capacity with flexibility, in order to produce the widest range of products and to reach potential customers.

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