ERGONOMIC ANALYSIS FOR SCOPE OF PRODUCTIVITY IN CHEMICAL PLANTS FRACTIONAL SECTORS

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With the globalized competitiveness in all sectors of industries, it becomes fundamental to analyze and remodel existing processes, as a constant process. Such processes can arise from routine continuous improvement through cost reduction or through analysis of the improvement of the working environment layout. In this field, work engineering has methods and tools to improve activities in order to meet requirements and consequent optimization of manufacturing. This work focuses initially on the ergonomic study of the productive environment of a plant where there are sectors of chemical fractionation, translating improvement for the company in the final process and demonstrating the other indicators, such as human resources, how important it is to study and change manual processes that were not previously analyzed.

Keywords: Ergonomic, Industrial production, Productivity
1. INTRODUCTION

In a competitive environment with a highly demanding market, a more in-depth study of business and manufacturing processes is required. In the global market, less efficient firms lose competitiveness due to the large number of options offered by the fall of customs barriers and the opening of markets (CORREIA et al, 2002). This analysis usually directs the development of the activity as a way to add value to the task. The sequence of processes is relatively complex and is influenced by various decisions and events that occur over time (WINDISCH; ROSER; SPRING-YUDEGO; SIKANEN; ASIKAINEN, 2013). However, efficiency will depend on the integrations between all processes that enable the delivery of a particular product or service. According to Salgado et al. (2013), most processes in an organization are formally documented, many of them through standard operating procedures (POPs), based primarily on server experience. However, according to Pyon, Woo and Park (2011), it is a basic premise of process management to map processes through a graphical representation, which will bring a more visual and procedural representation of all the activities that are encompassed in that task Pre-written. In addition to developing all production "blocks", process mapping can help solve the existing anomalies in various fields of activities, whether man-made or even machine-driven. The process mapping is also a highly recognized tool for the important role that it can play, since it assists in the evaluation of performance and understanding of the structural dimensions of the workflow, supporting programs to redesign the activities (CORREIA & ALMEIDA, 2002).

According to Barnes (1982), there are four approaches that must be considered in the development of possible process improvement solutions. They are: to eliminate all unnecessary work; Combine operations or elements; Modify the sequence of transactions; Essential operations. In order to meet these improvements, it is not enough to perform a mapping of the process and its aggregates. For the fractionation process, the analyzes to be carried out from the point of view of ergonomics should be primarily involved. It will demonstrate, according to the work environment, what will be the change needs to obtain a good working environment that allevies the productivity of the company as a consequence and not as the main object of study. This article focuses on how ergonomics can directly affect the productivity of an organization.

2. RATIONALE

In all manufacturing processes there are conditions for accomplishing the task that can be
improved or improved. In most companies, these improvements are realized in the view of productivity and reduction of production costs. Economic Engineering can describe the synergy between these two indicators. It applies its knowledge to alternatives derived from technical, financial and social factors, seeking to find the one that provides the optimization of the resources (HIRSCHFELD, 1986). These factors can be deployed and shared vision develops the Ergonomic issue as part of the process rather than in a separate direction. The vision should be shared in optimizing the resources of the best performance in that meets the productivity, reduce the productive costs and, as a primary analysis and consequence, reduction of the ergonomic risks. The study of house emblem is systematic, photographing the way the company saw before the ergonomic analyzes and filming the time needed to internalize and implement the actions, measuring their results and their effectiveness. As a science, ergonomics is concerned with the development and knowledge about human capabilities, limitations and other characteristics as they relate to designing interfaces between humans and other system components (Hendrick, 2008). This concern begins to appear as part of the manufacturing process.

3. METHODOLOGY

Among the methodologies used in this research and application of the concepts, were made:

a) Bibliographical reviews of several authors with the purpose of understanding how each one saw the ergonomics and their economic relations in the companies, their trade office and the interactions between the two areas.

b) Application of Participatory Observation methodology among employees of the company studied, according to management by processes and based on the guidelines of ergonomics and based on the reduction of operational costs to be reached by the company. Participant observation is a social research technique in which the observer shares, to the extent that circumstances allow, the activities, occasions, interests, and affects of a group of people or a community (Anguera, 1985);

c) We also performed some mapping of the company's processes to perform a quantitative study of how sub processes could be improved and / or eliminated.

Some theoretical references of Ergonomics, Process Mapping and Productivity will be treated. The relationships between the three themes will be presented in the case study, where the improvements in the productive system were implemented.
3. ERGONOMICS

3.1. Definition

There are several references that Ergonomics has. However, the concepts describe the same principle of the relationship between work and man. A practical concept would be that of Vidal (2008), where he describes the ergonomics with the function of understanding the interactions between human beings and other elements of a system and the application of the knowledge of it, with respect to theory, principles and methods, helping in the elaboration of projects and operant modes, optimizing the human well-being and the overall performance of a system. For ABERGO (2000), ergonomics is a discipline that seeks to modify the work systems to adapt the activities therein to the characteristics, abilities and limitations of the people with a view to efficient, comfortable and safe performance.

The concern of the productive system is well known, and companies that add material movements are increasingly concerned with the ergonomic value in the work sector. There is general concern in all sectors that encompass activities by process management. This includes services, information management and the companies themselves generating finished products. In spite of this growing concern, ergonomics has since been linked to the study of military activities and industrial production, and today it is possible to notice a greater mobilization focused on the issues of ergonomics in industrial environments (IIDA, 1998). The ergonomic aspect becomes stronger in sectors where there is greater influence of the stressors, such as physiological, psychic or structural problems of man. The first refers to the study of physical-physiological aspects and the latter two reflect the concepts of cognitive ergonomics, both of which are discussed in this paper.

a) Physical aspects

There are several methods of ergonomics with physical-physiological evaluation. Among them is the RULA method, which is a quantitative method used in general for the analysis of postural risk, be it dynamic or static, which includes parameters such as strength and repetitiveness of the tasks performed at the level of the upper limb (SERRALHEIRA, 2007). In this way, there is how to measure (directing the posture adopted by the worker in the work environment) how the positions interfere in the life of the collaborator and in the company as everything. The RULA is based on the OWAS-Ovako Working Posture Analyzing System, in which the postures adopted are represented by scores, which, together with biomechanical and muscular function criteria, classify the postural combination according to its load.
In addition to these methods, there are others that guide the quantification of positions, types of work and the influence that this exerts on the lives of employees. For the proposed case study, we will detail the RULA method and its applicability in the developed project.

b) Cognitive Ergonomics

Cognitive Ergonomics (EC) is a field of ergonomics that aims to explain how cognitive processes are articulated in the face of problem solving situations at different levels of complexity. It is important to emphasize that EC is not intended to elaborate general theories on human cognition (Green & Hoc, 1991; Hollnagel, 1997). Its role is to reconcile technological solutions with the characteristics and needs of users (Marmaras & Kontogiannis, 2001). Introducing technological aspects about the task can significantly improve the worker's own regulation. In this perspective, it is requested to contribute with a theoretical and methodological reference that allows to analyze how the work affects the human cognition and at the same time is affected by it (Hollnagel, 1997). Faced with a buoyant consumer market and greater demands on the end consumer, reducing production costs are basic roles that any company should establish as a guideline. One of the ways would be the construction of these concepts in the factory. In addition to reducing indicators of work safety (absenteeism, accidents with or without leave, etc.), the profitability of the organization gains by maximizing the productivity of the sectors, generating sustainable results in its departmental indicators.

3.2. Process mapping

A specific ordering of work activities in time and space, with a beginning, an end, clearly identified inputs and outputs, and finally a structure for action (DAVENPORT, 1994) is called a process. For Anjard (1998), the process is composed of a series of value-adding activities that produce output for a customer, all of which are output processors. Harrington (1993: 34) says that “processes are the key activities necessary to administer and / or operate an organization.”

<table>
<thead>
<tr>
<th>Scores</th>
<th>Actions to take</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td>Posture acceptable if not repeated for long periods</td>
</tr>
<tr>
<td>3-4</td>
<td>Investigate possibilities for requiring change</td>
</tr>
<tr>
<td>5-6</td>
<td>Investigate, make changes quickly</td>
</tr>
<tr>
<td>7 or more</td>
<td>Immediate Changes</td>
</tr>
</tbody>
</table>

Source: Aguiar, 2009
According to the same author's view, they are a logically interconnected group of tasks, which uses the resources of the organization to generate the defined results in order to support its objectives. There are several conceptualizations that delimit the types of process. According to Candido, Silva and Zuhlke (2008), the processes can be defined as:

a) Macroprocess: it is the identity of the management in the general organization chart, that is to say, it is the name by which the unit is known;

b) Process: based on the concept of process management, can be divided in the process of realization (the essence of the operation of the management, ie the reason why the clients drive it), support process (guarantee all the necessary subsidies for the development of the realization process) and management process (guidelines related to the management of persons and of the unit are grouped according to corporate norms);

c) Subprocess: grouping common affairs activities into a process;

d) Activity: operational sequences represented in the form of flowcharts.

According to Barnes (1982), there are four approaches that must be considered in the development of possible process improvement solutions. They are:

- Eliminate all unnecessary work;
- Combine operations or elements;
- Modify the sequence of operations;
- Simplify essential operations.

In discrete manufacturing companies, it is possible to understand how these solutions behave and lead to more critical analysis of problems. The process mapping will define the steps of each task with the execution of activities that will be developed by each interface of the process itself. The mapping usually follows the following steps (Biazzo, 2000):

- Definition of the boundaries and clients of the process, the main inputs and outputs and the actors involved in the workflow;
- Interviews with those responsible for the various activities within the process and study of the available documents;
- Creation of the model based on the information acquired and step-by-step review of the model following the logic of the author-reader cycle (where the reader can be both those who participate in the process and potential users of the model).

For the analysis carried out in the case study, only the process flow diagram will be discussed. The other concepts will be explored together with the concepts of Studies of movements and times, directed to the ergonomic factors in the productive process studied.
3.3. Productivity

According to Tupy and Yamaguchi (1998), in the traditional approach, the productivity measure presupposes that the production obtained results from the best practice or is the production of frontier (maximum production obtainable, given the quantities of inputs used). As Grosskopf (1993) describes, productivity growth can be defined as a net change in output due to the change in efficiency and technical change, the change in efficiency being represented by the change in observed product distance relative to its frontier; The technical change is represented as the displacement of the production frontier. Of the two approaches, the latter one described by Grosskopf may reflect almost unseen aspects, such as inefficiency and computes changes in efficiency, from being just a problem-maker to suggesting possible opportunities for improvement.

4. PRELIMINARY ERGONOMIC ANALYSIS

4.1. The company and the ergonomic factor

With one of the largest arsenals of blowing machines made of HDPE and PET (Polystyrene), the company under study is located in the Metropolitan Region of Salvador, with its Corporate Headquarters in the state of São Paulo. Your final product targets Hygiene and Cleaning items. To do this, it manufactures its own packaging in its producing units, becoming the critical stage of the process of filling the liquid products. Until then, there have been no ergonomic studies in the manufacturing environment, and process time flow mappings are relatively new to the organization. Everything that was implanted was part of an academic project that directed a case study to better apply the theoretical studies on Ergonomics and Productivity.

4.2. Description of the Productive process and analyzes

The overall sanitizing process can be described in the process flow as shown in Figure 1. It identifies the steps that are required to enter the fractional raw materials. The place of fractionation of these raw materials differs from the place of production, being another obstacle with the time factor of production. Each raw material obeys the dosage time they have, which varies according to the density and quantity of the product. After the inputs are added step by step in the reactor, the batch already completed is terminated and a Quality Control sample is sent to verify that the manufactured product complies with the company's internal specifications. If approved by the laboratory, it is discharged into one of the storage tanks,
depending on the version produced. If the fractioned raw materials do not arrive in a timely manner, the reactors will wait idly for service, generating production costs with energy, hour / machine, hour / man and maintenance losses. All these indicators affect the productivity of each reactor, since the available time will be the same for a smaller amount of loads that was produced, reducing its efficiency. The pressure generated by these products are ready and close to the reactors can generate measurements with losses in the physical-physiological area, as well as in the cognitive scope.

Figure 1 - Flow of the manufacturing process of sanitizing product A.

In the fractionation process, there are the weight surveys of the 200 kg tunnels. Operators perform a tilt the way they see (or regulate) the activity. In this way, there is no exact pattern of angulation and how each performs the fractionation.

As Augustine (2013) reveals, there is an adequate way to pick up weights and not directly affect the cervical, lower back with more cases of pain for people who work with weight.
In this example, the difference between the angles of inclination for the lifting of the weight is clear. Basically, reducing angulation is the best way to get a proper posture so as not to "sacrifice" the other components of the spine.

The preliminary analysis then revealed that, even with the physical effort reduction project, an adjustment should be made when there is a need to perform some fractionation in which the operator requires weight lifting. This adequacy should be made through training and follow-up of the evolution of reduction of pain felt by all those working in the sector.

In this way, there is how to construct a diagnosis of the whole time of the fractionation sector before applying the proposed improvements and methodologies.

a) The general postures of weighing and removals of material for fractionation are considered erroneous. Among the justifications, the lack of ergonomic techniques are among the most assertive, since this concept was incipient throughout the productive environment.

b) The weighing times were not standard, since in the 3 shifts (morning, afternoon and night) they performed the weighing tasks at different times. Some factors such as lack of standardization of movements, physical strength of each operator and "expertise" that each one held are the most relevant.

c) The weighing times have become a bottleneck for the production flowchart. Discrete manufacturing of batch production required the fractional raw materials and did not arrive in a timely manner for the other operators. This reduced the productivity of the reactors and led to the idleness of the operators responsible for the reactors.

Besides the occurrences of dissatisfaction, all the work carried out in this fractionation sector reflected in several of the company's indicators. Graphs 1 and 2 describe the aggravating factors of the process when focusing on the attestations given by operators during the year 2014. All
the certificates were counted by month and by type of illness. With each one separately and per operator, the inefficiency of solving the current problems in the organization may take on another scope, such as punishment of the operator, loss of credibility in his work and his punctuality in the workplace. Analyzing the process with the ergonomic aspects, one can perceive the sudden interference of the working methods and the use of the column as a tool and instrument that is poorly used in the operation.

Figure 2: Total attestations per shift

![Total Quantity of Medical Certificates](chart1.png)

Figure 3 - Total attestations for diseases

![Total Quantity for Diseases](chart2.png)

The greatest amount of attestation that the operators delivered was due to pain in the spine. This restricts the study of the work position with the cervical one and opens a range for the use of another type of instrument to carry out the fractionation. All the preliminary analysis was carried out in the year 2014, between the months of January and June.
Among other indicators, the most committed to the irregular fractionation are the accuracy of inventories (due to the fractions being raw materials and need periodic inventories) and production costs. The latter can be measured in several ways, including the cost of the operator’s failure to apply medical certificates.

Figure 4 - Cost of certificates from fractionation operators

5. FURTHER PROCESS ANALYZES

5.1. General improvements in the process

After the study of the mapping of the global process of production and application of the RULA method, some actions were proposed for the company and they were accepted. The implementation and deployment costs were raised in order to counteract the benefits that the company would have after all points were remedied. In this work, the processes before and after the application of the RULA method are shown, as well as the quantification of the positions that the operators exert in the activities of fractionation of the requested raw materials. This quantification is important to measure the risks of the positions operators offer for their activities. Optimizing a process with high levels of risk can bring several benefits, including self-esteem, motivation for work and consequent cost reductions with absenteeism, lack of operators, reduction of raw materials losses and constant changes in the work front.
5.2. New view of the flow chart of the fractionation process.

The process was then reviewed and performed a mapping to singular the data already described in this work, optimizing to the maximum the processes of weighing the raw materials:
6. CONCLUSION

The process time itself reduced and the higher productive efficiency was obtained after the application of the concepts of ergonomics in the fractionation room. According to the study, the process time without the modifications was 5 hours / shift.

The process time with the modifications passed to 3.2 hours / shift. This minimizes production costs since the fractionation of raw materials, besides being full time, happens for a faster and more effective vision. In addition, the most important of the whole process would be the adequacy of the work posture and the use of tools and machinery to replace the lumbar and cervical in the operation. They will now do the job only with the drive and displacement of the pump, it is not necessary several times the operator to perform the movements of 45 ° to do their activity.

The project was accepted in the company and it has made available all the financial resources to improve the working environment and to ensure that operators can take better positions in weight lifting and reactor operations.
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