

Macroergonomic analysis of an assembly sector of a furniture company¹

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Abstract. From of Macroergonomic Analysis of Work were diagnosed the main ergonomics demands in a furniture company in the city of Cambé, Paraná. Through this method we could identify the most problematic points of the analyzed environment for posterior solutions of improvement with the objective of increasing the working and phsychological quality of the employees, motivating their good performance and satisfaction.

Keywords: Macroergonomics, furniture company, solutions, improvement, quality

1. Introduction

The furniture sector of north Paraná highlight the region as an important pole of this national segment, this is the second biggest turnover of the country and is between those that more grow.

The furniture industry joins several processes of production, involve different raw materials and a great diversity of final products. It is segmented principally in function of the materials with which the furniture is made (wood, metal and others) and the uses what they are destined (in special, furniture for residence and for office) [2].

As for the home and extern market of furniture, this one has been substantially growing from the decade of 90s, second Meyer-Stamer [9], but small enterprises and others not so small keep on predominating in the furniture industry.

In spite of the stiff growth of this sector, the environment and the conditions of work offered to the workers do not present the same view, they still work in conditions that are far from being the ideal.

In this sense the ergonomics can contribute intensely to improve these places, since it is one of the most important slopes for the occupational health [11]. This science studies several factors that influence the performance of the productive system trying to reduce its harmful consequences on the worker [6]. Many ergonomic decisions are taken in level of the superior administration of the enterprise, which produces an improvement of the security, satisfaction, with reduction of mistakes and accidents, and improvement of the health and productivity in the enterprise completely [6].

Taking that into account, the present article takes as objective Analysis Macro ergonomics of the Work at an assembly sector of a furniture enterprise situated in the city of Cambé - PR, with the purpose of promoting the improvement of the physical aspects, environmental, organizational and interpersonal, aiming at a bigger quality of life of the workers and, consequently, the increase of the productivity of the enterprise.

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2. Bibliographic Revisions

2.1. *Ergonomics and Macro Ergonomics*

There are several definitions for Ergonomic, one of them says that the “Ergonomic is the study of the relationship between man and his work, equipment, environment and particularly, the application of the knowledges of anatomy, physiology and psychology in the solution of problems which rises from this relationship [6].

By the Brazilian Ergonomics Association is understood that "Ergonomic is the study of the interventions of people with technology, the organization and the environment, aiming at interventions and projects that aim to improve, in the integrated and not separated form, the security, the comfort, the well-being and the efficiency of the human activities" [6].

The International Ergonomics Association, an international extent, defines that Ergonomic (or human factors) is a scientific discipline, which studies the interactions between the human and different elements of the system, is the profession applying theories, principles, data and methods, projects that aim to optimize the human well-being and the global performance of systems [6].

All the definitions focus a bigger labor quality of the worker inside an enterprise, boarding physical, cognitive characteristics and organizational. The professionals who act in the ergonomics are called ergonomists and they carry out projection, projects and evaluation of tasks, posts of work, products, environments and systems, modifying and adapting them to the limitation of the people. All this evaluation of the ergonomists must be carried out in the global form.

The ergonomics aim to minimize the harmful consequences on workers, of factors that influence the performance of the productive system, consequently it tries to reduce the fatigue, stress, mistakes and accidents, providing bigger security, satisfaction and health to the workers. The efficiency and the biggest profitability of the enterprise come with consequence of the taken measures and not as principal objective.

Different from other sciences, the ergonomics has "official" date of birth on 12th July of 1949, where in this day it was joined, for the first time, in England, a group of scientists and investigators interested in discussing and in formalizing the existence of this new branch of the science, [6]. However the ergonomics only acquired status of a science more formalized from the beginning of the decade of 1950, with

the foundation of the Ergonomics Research Society, in England, [6]. The history of the Ergonomics suffered a long period of gestation, beginning probably with the first prehistoric man who chose a stone of format that better would adapt to his necessities and stretches out up to today to the work of the modern men, his equipments and environments.

The purpose of the ergonomics was extended from the decade of 1980. This extended version was called of macro ergonomics, what can be understood as a development and application of the technology of interface man-machine, in a level macro, in other words, in the whole organization. The ergonomics stopped being superficial, becoming much more ample, being able to include the coordinated action of hundreds and even thousands of workers and machines.

Macro ergonomics appeared in the United States like a form of answer to the American enterprises on the increase of sales of industrialized Japanese products, doing so that necessities of changes were recognized and that these should firstly suffer the process of acceptance and institutionalization part of all who were involved [15]. In practice, the Macro ergonomics is seen as the most recent traineeship of the Ergonomics [13].

His purpose is to evaluate, through a unique approach, four principal subsystems, including so the environmental, technological and interpersonal variables that interfere in the systemic interactions between the individuals and the devices of work, as a form of optimizing the productivity [7].

With evaluations of an ergonomist professional is very important the participation of the workers so the necessary changes and improvement of the conditions are applied inside the enterprise.

That because demonstrations of resistance to changes, even that they are not explicit or conscious will have to appear with the time, translated in low productivity and problems psychophysics [12]. In this way the participation of workers makes easier the introduction of changes in the work environment.

The Macro ergonomics is a different type of specialty of evaluation regarding the traditional ergonomic studies, since, its global vision of the system is what makes it called macro, whereas the traditional Ergonomics in front of it, started to be called Micro. The Macro ergonomics looks for a completely harmonious system, including so much the level macro, how much the micro [4].

When an approximation purely micro ergonomic is done, expressive improvements are possible. Frequently, meantime, large improvements in the health,

in the security, and in the productivity they are possible when an approximation really macro ergonomic is carried out [4].

Specialists consider the Macro ergonomic, nowadays, like a strong methodological tendency for management of enterprises, due to his amplitude and its direct relation with the organization of the work. In this sense its application appears more efficient than the traditional ergonomics.

3. Caracterization of the Enterprise

The enterprise located in the city of Cambé-PR, acts from 1998 in the branch of furniture, it began his production of craft furniture with natural fibers and subsequently the synthetic fiber was incorporated. His products contain raw materials like the natural fibers, synthetic fibers, aluminum and wood.

In the enterprise works its administrative and production sector. Pay attention to great distributors centers as Sao Paulo and Curitiba located very close to the furniture pole of Arapongás-PR.

It is divided in 11 sectors, being them: assembly, solder, polishing, end-line-production, craftwork, painting, woodworking, sewing, expedition, conservation and cleaning, and administration. They work 10 (ten) hours daily, Monday to Friday.

The flow chart (It imagines 1) following shows the structure of the enterprise and his productive process.

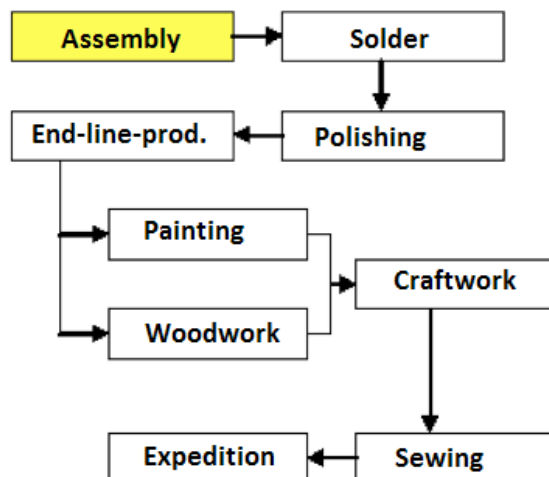


Figure 1 - Line production

3.1. The Studied Sector

The evaluated sector was the assembly sector, where there are assembled the pieces that compose the structures of a piece of furniture. This choice was done due to the bad conditions in which the workers work, as well as the repetitive movements and the machines used for them during the performance of their functions. In the sector of assembly the used material is aluminum.

12 Staffs, including the person in charge responsible to supervise the rest, compose the sector, they are all male and the age group is from 17 to 40 years.

The work shift takes place in the morning from 7:30h to 12:00h and in the afternoon from 13:12h to 17:30h.



Figure 2- Worker in the function of molding Aluminum



Figure 3 - Worker in the function of small solders



Figure 4 – Worker handling one of the machines



Figure 5 – Worker in the function of small solders

4. Methodology

The presented study used the method of Analysis Macro Ergonomics of Work (AMT), which consists of an evaluation with the participation of the workers during the whole methodological process [8].

According to the method proposed by Fogliatto and Guimarães [1], an interview was carried out with the workers for identification of Ergonomic Demand (IDE's). This one was carried out individually and it included 100 % of the sector, providing subsequently the preparation of a questionnaire, which was applied to all the workers participants of the first stage.

The questions of the interview were made a list to the environment of work in which they were developing his functions, it was asked so that they quoted the problems of bigger importance and what more was disturbing them during the work.

Was the next question carried out: "Quote three items in order of importance of what more disturbs you in the realization of his function? "

From the quoted items, an analysis was carried out and a questionnaire was subsequently prepared. The applied questions were based on the IDE's found and were answered by the workers by the marking of an "X" in a continuous supplied range jointed to the questions. This range was containing 15 cm with two anchors, one at the beginning and other one at the end of the line [14]. The marking had as a criterion for satisfaction (0) and for dissatisfaction (15).

For each question the arithmetical average was carried out, what it provided to reach the final result of this stage of the inquiry.

4.1. Interviews

The interviews were carried out individually, in a non-induced form, with an average duration of 10 minutes per each worker. It included 100% (12 workers) of the evaluated sector, being able to check so the real necessities for the position of the mentioned work.

It was asked the workers to quote three items in order of importance of what more it was disturbing them in the work environment.

The items reported in the interviews were organized in the order of quotation, being the weight of importance checked by the reciprocal one of the respective reported position, in other words, to the item mentioned in the worst position the weight was attributed $1/p$. Being so, the first reported item received the weight $1/1=1$, the second one $1/2=0,5$, and the third $1/3=0,33$.

Due to the small number of workers was possible to prepare questions referring to all the quoted IDE's. The data were tabulated in an Excel spreadsheet. From the results referring to each worker, IDE's had its added up notes, obtaining so the values of Chart 1 with the items organized from he most priority to the least priority.

Table 1

Outcome of the Interview.

IDE'S	Colaborators					
	1	2	3	11	12	Σ
			10			
Space		0,33	...			0,33
Place of Work			...			0,33
Danger of the Machine			...			0,33
Unleveled Floor			...			0,33
Ventilator's Noise			...			0,5
Fountain's Hygiene			...			0,66

Room Temperature	0,33		...			0,83
Solder's Smoke			...			0,99
Tidiness of the Place	1		...			1
Use of Mask			...		1	1
Talks at the Work Environment	0,5		...			1,5
Adequate Workplace			...	1	0,5	1,5
Machine's Powder		0,5	...	0,33		4,83
General Noise		1	...	0,5	0,33	7,83

4.2. Questionnaire

On basis of the results obtained by the interview a questionnaire was prepared containing 14 questions, all related to the pointed IDE's. The answers were valued, being measured by a ruler of 15 cm to obtain the right value of the marking of the worker, with the objective of showing his degree of satisfaction regarding the quoted items.

Soon after, there were added up all the values found referring to that question and the result was obtained by the arithmetical average. This procedure was carried out in all the boarded questions. This average defined the ranking of importance of the IDE's quoted.

The results can be seen in the Figure 6, where they were organized in a growing order of less satisfaction for bigger satisfaction.

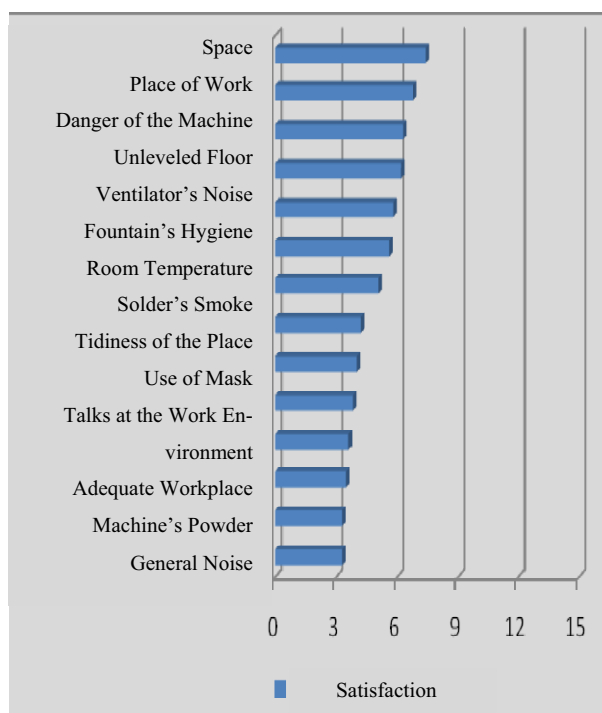


Figure 6 - Result of the Questionnaire

5. Suggestion of Improvement

Of the 14 IDE's quoted, there was noticed a great dissatisfaction of the first seven quoted, needing so a bigger attention, the values found are:

- General Noise (3,3 cm);
- Danger of the Machine (3,3 cm);
- Ventilator's Noise (3,5 cm);
- Machine's Powder (3,6 cm);
- Unleveled Floor (3,8 cm);
- Fountain's Hygiene (4 cm);
- Room Temperature (4,2 cm);
- Distance of the Place of Work (5,1 cm);
- Use the Mask (5,6 cm);
- Appropriate Place of Work (5,8 cm);
- Solder's Smoke (6,2 cm);
- Tidiness of the Place (6,3 cm);
- Talks at the Work Environment (6,8 cm);
- Space (7,4 cm)

5.1. Environmental Factors

5.1.1. Noise

The noise can result in an alteration of the alertness sense, sleeping disturb and others, and even the hearing loss, which can be temporary in the begin-

ning, but after "going deaf", repeatedly, can produce a permanent damage [3].

It is known that noise above 90 dB to begin to provoke physiologic damaging reactions to the organism, increasing the stress and the fatigue. These noises also make difficult the verbal communication. The intense noises have a tendency to damage tasks that demand much attention, mental concentration, or speed and precision of movements. The effects have a tendency to get worse after two hours of exposition to the noise. The noise produces moodiness, due to a forced interruption of the task or what the persons would like being doing, and that provokes tensions and headaches [6].

When the noise surpasses 90 dB, it is necessary to take some measures as:

"To act in the source: The most efficient measure to reduce the noise is to act straightly in the source. That means, for example, to redraw the machine or to substitute them for others, less noisy." [6]. This would be the solution, for the ventilators, which are ancient, causing strong noises.

To isolate the source: The sources can be shut away inside isolating cabins, to create a total or partial barrier to the propagation of the sound. The total enclosure consists in creating an isolating cabin around the source, leaving small openness for ventilation. Partial one consists in putting an acoustic barrier between the source and the receptor [6].

"To reduce the reverberation: The level of the noise in an environment depends on the intensity of his source and on the reverberation in several surfaces". Iida [6]. It can be reduced, when absorbent materials are put, like fitted carpets on the floor.

To move the worker: The worker can be removed from the noisy environment, for example, changing the layout of the factory. When possible, the noisy machines can be put in a remote place or far from place where there is bigger concentration of workers" [6].

"To adopt Administrative controls: To make the workers aware on the harmful effects of the noise and to subdue them to the training to avoid unnecessary exposition, or to use personal protective equipment. Also it is possible to adopt a system of rotation of the workers, to avoid the prolonged exposition of each one to the noise" [6].

"To protect the worker: The use of auricular protectors must be considered the last resource for defense of the worker, when all the other measures appearing ineffective or economically impractical." [6].

Taking into account the described options, it would be viable in order that the enterprise put away

the machines from most of the workers, even carried out also trainings where subjects like the unnecessary exposition to noise would be boarded and also as the best form of being protected against these damages.

5.1.2. Temperature and Ventilation

The zone of comfort is delimited between the effective temperatures from 20 to 24°C, with relative moisture from 40 to 80%, with a moderate speed of the air, order of 0,2 m/s. The present differences of temperature in the same environment must not be superior to 4°C [6].

The ventilation is an important aspect of the thermal comfort, since it helps to put away, for convection, the heat produced by the body. While moving the saturated air away from the skin, it makes easy the evaporation of sweat and cooling of the body. In industrial environments, the ventilation can have the principal objective of moving the contaminated air of aerodispersoids. A person needs a renovation from 12 to 15 cubic meters of air per hour. In conditions of heavy work, that amount must be doubled. To maintain the quality of the air in internal environments it is necessary to renew equivalent to at least the volume of this environment per hour [6].

The discomfort produces functional alterations that can affect the whole body. The superheating produces tiredness and drowsiness, reduction of physical performance and increase the risk of mistakes [3].

Regarding the powder produced by the machine, the use of masks is essential and to improve the ventilation of the place, favoring the reduction of the accumulation of the powder in the sector, for that the enterprise should adopt ventilators that offer less noise in several points of the environment, besides insufflators of air that allow better exchange of air in the place, which also will help to maintain the temperature more pleasant in the place of work. A more ventilated environment allows that the worker has a better oxygenation and, consequently, bigger performance in his function.

5.2. Equipments

5.2.1. Safety of the Machines

There are two classes of measures in order to increase the security in the operation of machines: those that act in the machine and those that act in the man. The first one, more efficient, takes place in the phase of projecting the machines and equipments, in a way to remove the dangerous points. The second could be building isolation in the machine or protec-

tion to avoid the human contact with dangerous points [6].

The one acting on the worker must be the last measure to be taken, due to the human beings to present variations of behavior and it cannot be wait that they are always attentive for the practice of safe acts.

Second Iida [6] some measures that can be taken are:

“To develop safe project: It is that which does not expose the operator to the risk. The removable parts are properly protected. In other cases, the products can be operated only after preventive security measures are taken. Another care refers to the elimination and lively corners that can cause injuries in case of collisions”.

“To isolate the dangerous part of the machine: When it is not possible to isolate the machine completely, must isolate at least those dangerous parts that do not demand constant contact with the operator. This principle is particularly applicable to the points of generation and transmission of movements”.

“To protect the dangerous parts of the machine: When the points of operation of the machine cannot be isolated, they must be protected by special devices like funnels, grills or protective apparatus. They differ from those of the isolation because they allow access for the placing and removing of pieces, but the hands of the operator must be kept on safe distances”.

“To interrupt the functioning of the machine: In case of an emergence, the machine can be stopped or disconnected through a mechanical device, like a steel cable, bars or levers”.

“To remove the operator of the dangerous area: The most simple form is to put the machine or its dangerous part out of the reach of the operator building a physical barrier between them. Use of special tools: The use of special tools to put or to remove pieces of the point of operation. There are many types of pliers, tweezers and other tools for this finality”.

“To use personal protective equipment: The parts of the body with bigger risks of accidents can be protected by the personal protective equipment (PPE), as, gloves, boots, helmets and glasses”.

For a bigger safety of the workers of the enterprise, there was proposed the protection of dangerous parts of the machines, the use of special tools for handling them and to carry out trainings emphasizing the importance of using the PPE's.

5.2.2. *Use of Masks*

The PPE's generally are uncomfortable and they interfere in the performance. The masks make difficult breathing, besides, the efficient filters do not work for gases.

Therefore, the PPE's must be considered as the last "trench" in the defense of the workers, to be used only in cases in which other resources are impracticable or very expensive [6].

However, when not possible the removal of the worker from the area that offer risks, is extreme important that the use of PPE's is done.

5.3. *Physical Factors*

5.3.1. *Unleveled floor*

Improvements will have to be done in the physical space, like the reform of the floor making it leveled so that the transport of pieces becomes safer in the place and principally the transit of the workers themselves. Consequently this would avoid the accidents of work, as well as it would make easy the hygiene of the place.

5.4. *Organizational Factors*

5.4.1. *Hygiene of the Drinking fountains*

A person needs not only food, to be provided with energy, but also water, to maintain a balance of running water. The average necessity is of 35 g of water for each kilogram of weight of the body, in a period of 24 hours (2 -2,5 liters / day) [3].

The lack of cleaning in the drinking fountains can bring harms to health of the workers and the dirty aspect does so that these stop ingesting the appropriate amount of water.

There will have to be adopted places special for the use of the drinking fountain, avoiding so that the produced powder does not contaminate the place, allowing that the workers have access to a clean drinking fountain, the maintenance of the fountain will also be suggested.

5.4.2. *Cleaning of the Place*

At present the workers carry the cleaning of the place of work out once weekly. For a bigger hygiene, it will be suggested what is available every day to the workers twenty minutes before the end of the work shift so them carry out the cleaning of the place, maintaining so organized and a clean environment.

5.4.3. Talks in the Environment

The introduction of production marks in the studied sector can influence in reduction of conversation in the place of work, taking so the workers to an increase of productivity. Consequently lifting up the degree of satisfaction of the collaborators and of the enterprise.

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