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PREVENTION OF THE CONSEQUENCES OF SPECIFIC STRESS FOR ACTIVITIES IN THE CLOTHING INDUSTRY

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Abstract: *This paper aims to draw the attention of manufacturing engineers upon the role and importance of ergonomics in business success. To this end, the way workplaces are organized in different garment companies has been analyzed to find solutions for their redesign, streamline the activities performed and eliminate the stress and fatigue factors. The results, obtained through own research in several garment companies, were compared with those of similar studies published in the literature and with the information of the ISO 1126 Ergonomics Standard and concluded that: the approach of the ergonomic principles of the activities in the garment industry produces new performance solutions that are different from those of the top management. Future studies on the long-term effects of the consequences of work-related stress could show that "ergonomics is a source of profit".*

Key words: *ergonomic workplace design and redesign, stress at work, garment industry*

1. INTRODUCTION

A company's success is usually measured by the profit that results from its hard work in the financial year. Every owner of a business is delighted when their business has found a niche in the competitive market. They feel successful when they have achieved what they have been striving for. Success is measured by the overall satisfaction the company has achieved in terms of profits made, employee satisfaction, a safe workplace, advanced technology, excellent infrastructure and customer satisfaction.

Of all the industries that produce soft goods, the fashion and apparel industry is particularly difficult to manage because there are many dynamic factors to deal with: competitors, new materials and technologies, trends, customer demands and, finally, employees. Success in this industry is expressed in making the brand known and retaining customers. For all industries producing soft goods, including the garment industry, the human factor is very important as it is involved in all activities of the manufacturing process. The following factors determine the worker's performance: the level of personal education and goals (basic education or training); the type of work (conceptual activities, repetitive activities, different work tasks or physical activities); the type of equipment or technology he has to use during the work shift; the work schedule; the working conditions (environment, facilities and type of equipment he has to use, same level of complexity); whether he has to cooperate with other colleagues and his professional future (whether he can reach a higher professional position if he performs well).

Ref.[7] mentions that ″ the science of work deals with the parsing and designing of working systems and working environments, aiming to establish, on the basis of scientific knowledge, all the necessary measures that would improve and facilitate the work and life of a man in the industry.″ The organization of a workplace according to ergonomic principles consists of optimizing the man-machine environment system by adapting working conditions to the

physical, psychophysical and physiological nature of human beings, considering the relevant differences between people in relation to their work and their workplace. Ergonomics increases the efficiency and productivity of production or business systems and improves people's health, safety, and comfort in their working environment [1,4].

In this economic context, the current "industrial" age has had two notable effects:

- The diversification of the potential hazards and occupational diseases that can occur in or be caused by the work process, which made research into their effects increasingly relevant,
- It has raised awareness regarding the importance of humans as the main resource that ensures the existence and progress of society.

These two phenomena have led to a departure from the strictly mechanistic approach and the emergence of new types of relationships:

- The society has started to emphasize everyone's quality of life and to take steps to ensure it, as well as to devise ways of protecting the individuals from the risks to which they are exposed.
- To truly protect the workers, everyone involved (the employer, designer, and the user of the workplace) must undergo a continuous educational process in order to bring about a change of mentality and to acquire of the right skills that prevent overwork.

According to the International Labor Office, deaths caused by accidents and occupational diseases occur every year despite all of these changes. In addition, it is estimated that 2-4% of the gross domestic product can be attributed to costs and losses due to occupational accidents and diseases each year. In the European Union, work-related stress is the second most common work-related health problem after musculoskeletal disorders. It affects 28% of the workers in the EU. Preventing the consequences of work-related stress is one of the objectives identified in the European Commission's Communication on a new strategy on health and safety at work. The executive Vice President for an Economy that Works for People, Valdis Dombrovskis, said: "The EU's legislation on occupational safety and health is essential for protecting almost 170 million workers, peoples' lives and the functioning of our societies. Healthy and safe work environments also reduce costs for people, businesses and society as whole. We need more EU action to make our workplaces fit for the future" [12].

The current scale of these problems calls for a rethinking of the level at which worker protection needs to be addressed, an objective that should perhaps have the same priority as the economical ones.

At the European level, the importance of knowledge of and compliance with ergonomic principles is lobbied for by the European Foundation for the Improvement of Living and Working Conditions (Eurofound), whose mission is to shape and create better living and working conditions through actions that develop and disseminate knowledge relevant for this purpose. In addition, a set of ergonomic regulations covering the European Union's requirements in this area has been developed at the Common Market level:

- EN 614-1 / 2009/General terms and principles related to the basic ergonomic rules;
- EN 614-2/Ergonomic principles - the interaction between the design of work equipment and work tasks;
- SR EN ISO 14738/2009: Machine Safety. Anthropometric requirements for the design of working positions on machines;
- EN ISO 10075-1/ Ergonomic principles related to mental stress - general aspects and concepts.

These rules should be applied in designing workplaces because the way this is done will heavily influence the way in which companies are organized and will have a direct impact on the time that is necessary for each relevant process, as well as on the conditions that the workers need to carry them out with minimum energy consumption and without endangering themselves.

The European regulations is perceived differently in the garment companies depending on what kind of management they have. In companies with outdated management, the

practical application of ergonomic principles is associated by many managers with ergonomic chairs (and if we try to go into detail, we come up with the idea of a comfortable chair that is shaped after the human body), neglecting or regarding the contribution of other factors that can cause stress for the employees as implicitly addressed. This article explores how these European regulations are implemented in the garment industry.

2. THE INFLUENCE OF TECHNICAL EQUIPMENT AND ACTIVITIES CARRIED OUT IN THE CLOTHING DEPARTMENTS ON THE MAIN RISK CATEGORIES

In apparel industries where people are directly involved (activities that require handling), the usual posture for their development is the seated position [3,8]. For activities performed on automatic or semi-automatic machines (e.g., articles for the automotive industry), standing is recommended in the literature and in daily practice. For these sewing operations, this type of posture is recommended for the following reasons: the characteristics of the machines (dimensions, type of use, specificity of the articles produced) and because in this posture the degree of static load is lower.

In the garment industry, seated workstations represent more than 85% of all workstations, so the organization of this area is very important to achieve the proposed objective. In this context, the type of chair, the working position, the light source and the sequence of work steps are crucial and must be specifically dimensioned according to the type of equipment.

There are two types of companies when it comes to the influence of technical devices on the ergonomics of workplaces:

- Classic factories, which are equipped with relatively outdated sewing machines, often with unsuitable environmental conditions (e.g., Lighting), where ergonomic concerns are limited to ensuring that the height of the machine operator is suitable and that the machine is equipped with a seat adapted to the biological characteristics and mental health of the operator,
- Modern factories that have invested in the latest technologies, where machines are increasingly complex, expensive and wear out more quickly, and where the operator must be able to adapt to the demands, both in terms of expertise and the psychological and physiological requirements in order to effectively perform the tasks at hand (a chain of errors is very expensive).

This type of industry has certain peculiarities, such as [2,5,6,9]:

- The great variety of manufactured products, which is heavily influenced by the change of seasons;
- The crucial role of human resources in manufacturing the final products;
- The predominance of manual-mechanical operations in comparison with the automated ones;
- Many types of processes;
- A strong interdependence between the stages of the same technological process;
- The influence of the costs of the material on the total production ones.

These are just some of the reasons why garment companies must plan and manage the production process in accordance with the tasks and objectives set by managers.

If we compare the businesses in terms of workload, we can note that:

- The specific task requirements in the garment industry are the same regardless of the equipment, even if their distribution between the operator and the machine varies;
- Technology always contributes to a reduction in the necessary physical effort and it requires a sometimes significantly larger mental input from the operators.

The following categories of latent risks may occur and affect both the physical and mental performance of workers [3,8,10]:

- Pain in the upper extremities (muscles - tendons - skeleton) and back due to incorrect working posture, repetitive manipulations or excessive muscle tension (strains, especially when working on an assembly line or in front of a computer screen). Researchers have already identified symptomatic patterns

associated with certain tasks, such as: ironing, which is correlated with elbow conditions; cutting, which is associated with symptoms in the neck, shoulders, and wrists (including carpal tunnel syndrome), and back afflictions; and hand sewing, which has been proven to affect upper extremities;

- General fatigue of the body (intense and prolonged, e.g., in performing tasks such as manual baling or stacking boxes) or local muscle fatigue (e.g., in standing for extended periods of time);
- Mental fatigue (e.g., caused by monotonous tasks with a very short production cycle or by ones requiring one to process a lot of information in a short amount of time, such as the computer work that is required to design patterns);
- Accidents caused by human error (especially when dangerous machines, such as cutting machines, are operated improperly or without taking the proper number of breaks);
- Environmental damage (e.g., when products are cleaned by using polluting chemicals).

The fact that in garment companies the production process of marketable products is directly carried out by the workers (in most workplaces) makes it necessary to improve their workplace conditions by taking specific measures [11,13]. For this purpose, one must identify and study the potential hazards, the factors that determine them and, implicitly, the necessary prevention measures (determining the proper way of designing and configuring the workplace).

3. STEPS TOWARDS THE ERGONOMIC DESIGN OF WORKPLACES IN CLOTHING COMPANIES

To analyze a workplace from an ergonomic point of view, certain steps had to be taken [5,14]:

a. Documenting and recording the data needed to design a new workplace or choosing the workplace that is going to be analyzed. The study consisted of analyzing existing sewing workstations that have been selected based on their efficiency in carrying out the same technological operation. We chose this criterion to be able to comparatively analyze the physical, visual, mental and psychological stress the operators are subject to, as well as their intensity.

b. Collecting the necessary data for the study, a process which consisted of obtaining information on the organization of the workplaces that were going to be analyzed. The selected workplaces were analyzed by considering the influence of the physical (surface, work equipment, workers, type of work) and environmental factors (local and general lighting, as well as heat).

c. Critically examining the existing situation considering the investigations that had been carried out by using the survey method. The data collected in this way were then used to address the identified shortcomings and to find better solutions.

d. Redesigning the ergonomic organization of workplaces was a process that consisted of developing new solutions based on correct ergonomic principles and rules (by physically redesigning the configuration of workplaces to reduce the amount of stress that the workers are subjected to).

In choosing the optimal (implemented) design option, the economic efficiency of the proposed changes was also considered (in practice, ergonomists have to ensure the correct that the workstations are correctly designed, and most importantly, they must implement solutions that reduce risks in situations for which issues have been reported). The results obtained when going through these stages can be evaluated according to the standards set by the work ergonomist, they can be used to determine the analytical profile of the workplace (based on assessments), or they can be used for the purpose of finding measures that improve the existing situation (as in the present study). From an ergonomic point of view, the central element of the work system is the performer, whose activity is influenced by the quality the input they are provided with, influencing other elements of the organizational environment. The practical benefits of reorganizing work stem from:

- Defining the essential structural elements of all effective subsystems within the company;
- Spatially delimitating the areas where each specific process is going to be carried out;

- The possibility of correctly and timely allocating all resources;
- Precisely assigning the responsibilities concerning each of the different types of processes that have to be carried out;
- The possibility of individually tracking the results achieved for each structural element;
- Continuously improving the company's working methods and information system.

Depending on the stage in which the man-machine system currently is (design or in use), one can talk about preventive ergonomics or correction.

4. SPECIFICS OF THE ERGONOMIC DESIGN OF SEWING MACHINE WORKSTATIONS.

The main ergonomic principles that should be followed in the workplace are employing equipment and tools suitable for the purpose, keeping repetitive movements to a minimum, avoiding awkward positions and postures, using equipment for transporting and lifting heavy objects or using safe manual lifting methods, making proper use of eye and respiratory protection against excessive noise and heat, and also observing regulated rest periods.

One should be extra cautious in what concerns standing and sitting positions, and one should choose between them by considering the following: workload, power requirements and legroom. In the garment industry, most workers perform their tasks while keeping a statical position, within the limitations imposed by the sewing machines. The advantages of this kind of position are that the legs do not have to support the weight of the body, harmful positions occur less frequently, and the worker needs to make less effort.

According to the 1126 ISO Standard, a correct statical position is characterized by the following: a symmetrical posture, parallel horizontal axes, the legs are slightly apart (30÷45o) and perpendicular to the floor, the upper body is perpendicular to the chair, the hips and the calves form an 115^{o} angle, the soles are on the floor, the head is tilted at a $20\div 25^{o}$ angle, the forearms are almost horizontal (raised at an angle of at most 25^{o}), while putting less strain on the circulatory system. As far as the physical design of seated workplaces is concerned, the ″working height″, the ″placement level″, and the ″accessibility neighborhood″ are closely related and are therefore always considered.

Regardless of the activity the worker has to perform, when ergonomically designing the workplace, one must take into account that:

- The working height should be adapted to the dimensions of the worker's body, as the height of the working surface should allow them to rest their arms;
- The height of the seat must be adjustable so that the worker can set it according to their height, as the machines have a fixed work surface;
- The working area is usually enlarged for certain sewing operations by attaching worktop extensions. The latter must allow the worker to easily reach the components on the table;
- Leg workstation: there must be enough space under the worker's machine so that they can move their legs freely.

Design flaws such as the control moves and postures that the machine imposes upon the worker (outstretched, raised arms, holding heavy objects in the hand, curved back, twisting and bending their body, keeping the arms above the level of the heart) that immobilize part of the body in the long term, or adjustable work areas (fixed, rigid), where no movement is possible without moving the fixed or movable elements of the workstation, have a long-term detrimental effect on the user and should be avoided.

For example, if we analyze the physical configuration of the workstation in Figure 1, we find that the worker:

- Cannot lean her back against the backrest of the chair;
- Has her shoulders pulled too far forward, resulting in a stooped posture;
- Will experience back pain, even if she moves her back closer to the backrest after a long period of time, partly due to the screws of the seat unit (the seat is unpadded);
- experiences considerable pressure on the blood vessels in the gluteal area, especially because the chair is not padded.

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Fig. 1. Configuration of workstation.

Fig. 2. Foot position.

Fig. 3. Sewing the leather logo (simple sewing machine).

Fig. 4. Sewing the leather logo (semi-automatic sewing machine).

Another problem that sewing machine operators often experience is that one footrest on the machine frame while the other one presses the pedal. In theory, this position violates the provisions of 1126 ISO Ergonomics Standard, as it is an uncomfortable one if the operator is forced to sit for a long period of time. However, if the pedal is located on an (asymmetrical) edge, the operator must operate it with the same foot throughout the entire work session (Figure 2).

The workers that operate semi-automatic/ automatic machines can briefly rest when working on the machine (while the latter is sewing the buttonhole or the bag), and this enables them to change their position for a short amount of time, thus relieving muscle tension.

To avoid mental stress, conditions at stationary workplaces must enable the worker to perform their tasks without any constraints, in a position that does not cause fatigue easily, and provides the greatest degree of comfort.

Workers on simple sewing machines must make sure that they maintain the same position throughout the whole work process. For this purpose, the neck, shoulder and back muscles are used extensively, and they can easily be strained if the dimensions of the workstation are unsuitable. For example, a worker who lines a product must put in less effort than one who makes mouldings on a chest.

Case study: The influence of the workplace technical equipment on the demands on the worker

The most common types of stress to which workers in the garment industry are confronted are the following:

- Muscular stress due to static and dynamic loading;
- Stress from static strain occurs due to factors such as muscle strain, muscle compression, organ compression and impairment of respiratory and digestive function;
- Eye stress, which can arise from faulty glare as well as inadequate lighting or the presence of reflections on the work surface, the distance from the eyes to the work surface (the eye-task distance), uncorrected visual defects;
- Mental stress, which is an important factor, mainly due to the need to make quick decisions when full information is not available;
- Nervous stress, which can be caused by the work pace, the background noise near the workplace, the conditions that must be met in setting up the workplace, the complexity of the task and the required level of quality.

These requirements vary according to the type of work equipment. To better illustrate the types of stress to which the human body is subjected during a working day, this case study analyzed the ones that arise when performing the

same activity at different workplaces using different techniques. To illustrate this, we compared attaching a leather badge using a simple sewing machine with a thread cutter to performing the same task by using a semi-automatic machine. The process of attaching a leather logo was first analyzed for the case in which the task is carried out by using a simple sewing machine (see Figure 3).

The analysis of the types of stress that arise when performing the task by using the simple sewing machine with thread cutter can be summarized in the following (see Table 1).

The same technical operation is achieved with a semi-automatic machine (Figure 4).
The types of stress that arise when using the automatic contour sewing machine are listed in the Table 2. If we compare the two ways of performing the task, which differ in terms of the type of technical equipment that is employed, we find that:

- The worker who applies the logo by using a simple machine will develop more health problems over time due to the physical demands of the activity;
- More automation and power of the machine, is correlated to less physical stress;
- A higher level of automation and power of the machine also requires a higher degree of concentration from the worker.

Table 1

Types of stress that arise when using a simple sewing machine with a thread cutter.

Strain type	
Muscle strains	• Back muscles strain, as this is the most used muscle group; • Spine strain, as the worker assumes a slightly bent posture and maintains this posture until the end of the work session; • Wrist strain, as the worker must hold the logo in the patterned position while attaching it, and this can lead to joint afflictions over time; • Gluteal muscles strain due to the stiffness of the chair, which is not padded; • Calf strain resulting from maneuvering the pedals of the sewing machine
Strain on the eyes	• The distance of the eye from the machine is the right one; the eyes are strained because the person must carefully follow the edges of the logo so that they do not run over them while attaching it. • Properly lighting the workplace by using additional local lighting.
Mental strain	• A high level of concentration is required as the quality of the final product depends entirely on the worker's skills.
Nervous strain	• The noise level is within a suitable range for a factory, namely 70-80 db.

Table 2

The types of stress that arise when using the automatic contour sewing machine.

Strain type	
Muscle strain	• Back muscles strain, as this is the most used muscle group. In this case, it is easy for the worker to change the position of their back for a short amount of time (which corresponds to the one when the logo is being sewn). Moreover, since the logo is fixed in a template, the worker has their hands free. • Prerequisites. • Gluteal muscles strain, as the chair is not padded. There is little strain on the leg muscles, as the worker only presses on the pedal at the beginning of the process. • There is little strain on the hand, as the worker does not hold the logo while it is being sewn.
Strain on the eyes	• The distance between the eye and the machine is suitable; • Appropriate lighting during work
Mental strain	• Programming the vehicle requires mental effort, but this is usually done by the mechanic and not the worker.
Nervous strain	• The noise level is within the range that is acceptable in a factory (70-80 dB)

5. CONCLUSIONS

The garment industry should focus on creating good working conditions to reduce injuries to its workers, because there is still a lot of room for ergonomic improvement in the garment industry. With proper training and instruction, machine guarding, personal protective equipment and ergonomically designed work systems, garment workers can produce in safe and healthy workplaces (similar with the findings and discussions provided by [15-18].

The paper explains why the protection of the physical and mental safety of workers is worth every effort:

- Sensible investments in modernization can significantly reduce the physical stress the workers are subject to;
- the higher the level of automation and performance of the machine, the easier it is for the operator to focus on the task at hand.

Properly informing the employees regarding the reasons why one should stick to the right postures and why one should correct unhealthy habits, as well as stressing the importance of properly operating the existing machines, can mitigate the stress that is caused by the tasks at hand, and can prevent the employees from being overworked.

Future studies will be developed based on contractual relationship in the framework of different university – industry collaborations [19], and by considering modern methods and tools for the ergonomics risks assessment [15-17].

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Prevenirea urmărilor solicitărilor specifice activităților din industria confecțiilor

Rezumat: Lucrarea își propune să atragă atenția inginerilor din domeniul confecțiilor textile asupra rolului și importanței ergonomiei în succesul unei afaceri. În acest scop, în diferite firme de confecții textile, a fost analizat modul de organizare a locurilor de muncă pentru a identifica soluții de reconfigurare a acestora, în scopul eficientizării activităților prestate și de eliminare a factorilor de stres sau oboseală. Rezultatele obținute din propriile cercetări au fost comparate cu cele ale unor studii similare publicate în literatura de specialitate și cu prevederile standardului ISO 1126 - Ergonomie și au determinat următoarea concluzie: abordarea pe principii ergonomice a activităților din industria de confecții textile, poate conduce la identificarea unor noi soluții de performanță, distincte de cele propuse prin strategia managementului de top. Prin studii viitoare asupra efectelor de lungă durată a urmărilor solicitărilor generate de muncă, se poate demonstra că „ergonomia este o sursă de profit".

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