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ERGONOMIC ANALYSIS OF THE WORK OF THE TIG WELDING PROCESS IN A RESEARCH LABORATORY

João Vitor Vanzella dos Santos[1]*

Yuri Balczareki Potrich[2]

Gabriel Campos Baba[3]

Lizandra Garcia Lupi Vergara[4]

Tamires Fernanda Barbosa Nunes[5]

Juliana Schmidt Teixeira[6]

Abstract

The text addresses the importance of ergonomics in the interaction between people and machines, highlighting its role in improving system performance and minimizing ergonomic risks. It focuses on Ergonomic Work Analysis (EWA), which aims to understand and identify the ergonomic risks to which workers are exposed, especially in welding environments.

A study is presented that was carried out in a TIG welding research laboratory, where the ergonomic risks associated with welding activities were analyzed. Using various analysis tools, such as the Ocra Checklist, TLV HAL, OWAS Checklist and RULA Method, postural and repetitive problems that affect the health of operators were identified.

Based on the results of the analysis, ergonomic recommendations are proposed, including replacing furniture, adjusting chair and table heights, and using appropriate PPE. Improvements to the work environment, such as increasing lighting, are also suggested.

It is concluded that, despite the low workload in the laboratory, ergonomic risks are significant and should be monitored continuously. It is recommended that the proposed measures be implemented and that constant monitoring be carried out to assess their impact on workers' health in the long term.

Keywords: TIG Welding; Ergonomic Work Analysis; Laboratory.

1. Introduction

Ergonomics is the study of the interaction between people and machines and the factors that affect such interaction (BRIDGER, 2003). Its objective is to improve the performance of systems, improving human-machine interaction, through interventions that allow changes in

[1] UFSC. * joaovitorvanzellads@gmail.com.
[2] UFSC.
[3] UFSC.
[4] UFSC.
[5] UFSC.
[6] UFSC.

the interface of these systems, in the occupational environment or even in the organization of work.

The Ergonomic Work Analysis (AET) allows the understanding of the work system in a systematic way, allowing the analysis of the activities performed by the operator during his working day and how the environment interferes with the worker's performance. Through the ETS, the ergonomic risks to which the worker is exposed can be identified, leading to solutions to eliminate or minimize the effects of such risks (ABRAHÃO et al., 2009).

Professionals who are current in the welding process, due to the nature of their function, are commonly exposed to musculoskeletal disorders; respiratory problems; effects of UV radiation; burns from sparks and splashes; noise; vibration; accidents; vision, (SILVA, 2003). The ergonomic view for the activities developed by welders allows the potential risks arising from such activities to be identified so that control measures can be implemented in order to eliminate or minimize them.

The welding process is widely used for joining metals, due to its accessory costs and the versatility of the process. For Magrini (1996), welding is a process of joining materials, giving continuity and maintaining their mechanical and chemical properties. It can be accomplished by merging the parts, or by merging by adding another material. TIG (*Tungsten Inert* Gas) welding is commonly used for welding parts of smaller thickness and when seeking to ensure higher quality. An electric arc is formed between a tungsten electrode and the part, which is responsible for fusing the material, and if used, the addition material, and effectively joining the parts (MACHADO, 1996).

Due to the need for precision linked to the TIG welding process, ergonomic risks related to the static sitting posture and the repetitiveness of the welding process are common during the working day. In view of the above, the objective of this work was to carry out an Ergonomic Analysis of the TIG welding work in a research laboratory, to identify the risks related to this activity, and subsequent recommendations for improvements to the workstation in question. Aiming to reduce the worker's exposure to the identified risks and improve performance at the station. The position analyzed belongs to LABSOLDA, a welding laboratory linked to the Federal University of Santa Catarina (UFSC).

2. Development

The methodological approach adopted in the present research follows the five stages of the Ergonomic Analysis of Work (GUÉRIN et al, 2001), as shown in Figure 1.

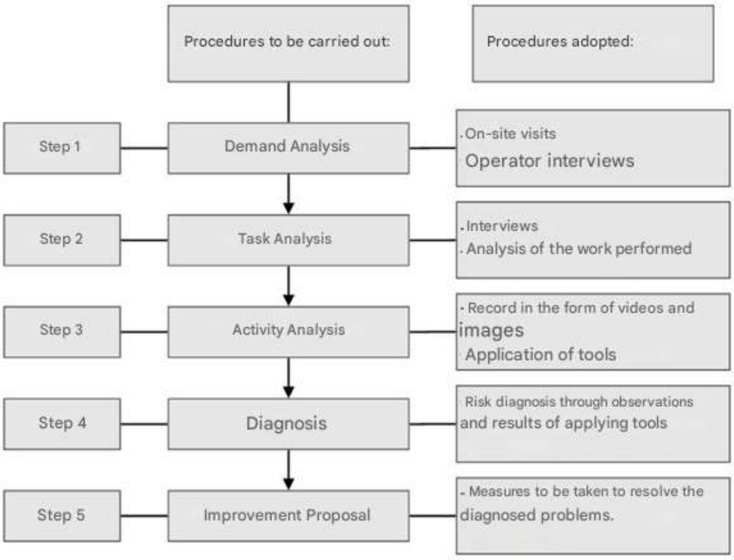

Figure 1 - Methodological procedures adopted in the present study.

The activity analyzed was the TIG welding of small steel parts for later analysis and study of weld quality, due to ergonomic risks related to static sitting posture and repeatability. The TIG process makes use of an electric arc between the tungsten electrode and the workpiece, surrounded by a shielding gas.

For the analysis of the task, a semi-structured questionnaire applied to the operator was used, containing questions about the conditions to which the worker is exposed during work in the laboratory, as well as questions aimed at identifying physical, cognitive and organizational ergonomic demands. The ergonomic risk mapping was performed during the demand analysis with the aid of the semiquantitative tool for failure mode and effect analysis or FMEA (*Failure Mode and Effect Analysis*) (SANTOS, 2010; PEREIRA, 2012). The determination of the indices and levels of risk factors was based on the approach proposed by Santos (2010).

The *OCRA* Checklist, *Threshold Limit Value for Hand Activity Level* (TLV HAL), OWAS *Checklist* and RULA Method were the ergonomic analysis tools used to investigate the demands raised, the analyses were carried out with the help of the demo version of the *Ergolândia* software.

The *OCRA Checklist* was used to measure the risk of biomechanical overload in the upper limbs, considering the distribution of breaks during the workday and assessing the risks to the left and right sides of the body, separately (OCCHIPINTI; COLOMBINI, 1996). The

TLV HAL method aimed to evaluate the risk factor related to repetitiveness in the work environment, more specifically for hand activity (LATKO, 1997). The Owas *Checklist*, developed by Karhu, et al. 1977, makes use of the record of the typical postures of the operator during work, as well as the frequency and time in which the operator spends in these postures, determining the resulting effect on the musculoskeletal system. The RULA Method, or *Rapid Upper Limb Assessment*, made it possible to assess the posture, strength and movements of the upper limbs, in order to verify risks to the operator's health.

3. Findings

3.1. Demand Analysis

The operator during most of his time at the workstation is in a static sitting posture, performing repetitive precision activities with his arms and wrist. There is no history of leaves due to repetitive strain injury (RSI), however there are complaints about the table and chair. The ergonomic mapping performed with the aid of the FMEA allowed the identification and prioritization of the potential ergonomic risks to which the worker is exposed, Figure 2.

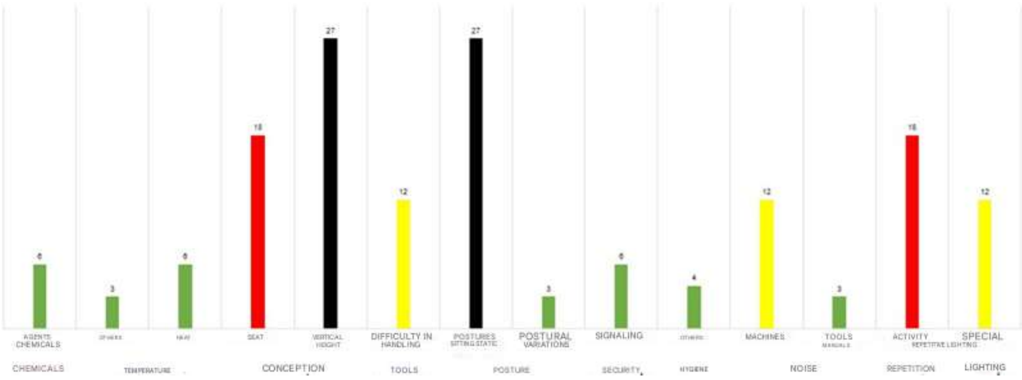

Figure 2 – Ergonomic risk mapping

In red there are substantial risks and in black intolerable risks, to which the worker is exposed. Which are later investigated during the AET.

3.2. Task Analysis

The processes of defining the welding parameters on the TIG welding machine, transporting the parts to be welded to the welding bench, cleaning the parts, verifying the need for sharpening or replacing the tungsten electrode, and finally, welding the parts characterize the operator's duties during his working day. In view of this scope, the intervention region is limited to the space used during these processes, as well as the way in which the operator uses this space.

The machines used during the process are the TIG welding machine and a grinder for sharpening the welding electrode. The process inputs are: small steel parts; product for cleaning the part (alcohol or stripper for stainless steels); tungsten electrodes; addition material; argon gas; electrical energy. The outputs are: welded part; argon gas; heat; gases from the use of paint strippers; radiation.

The general characteristics of this workstation are: work in a closed place with regular schedules, in which the operator does not spend an entire shift welding, both due to pauses required during the process, and due to the variation in demand. There is almost no loading effort carried out at this station. The analysis carried out considered the volume of critical service: two batches of ten specimens. Through an interview with the operator, the technical, organizational and environmental conditions were evaluated. There were no reports of cognitive or organizational problems on the part of the operator.

3.3. Activity Analysis

The analysis of the activity was carried out through the recording of videos and photos, however, it was not possible to make recordings or take photos during the welding operation, due to the intensity of the light emitted by the arc, which impairs the image quality. Therefore, a welding simulation without turning on the arc, in order to take measurements and analyze the operator's posture, was performed, Figure 3.

Figure 3 - Operator at the workstation performing welding simulation.

The flow of activities performed by the operator is shown in Figure 4.

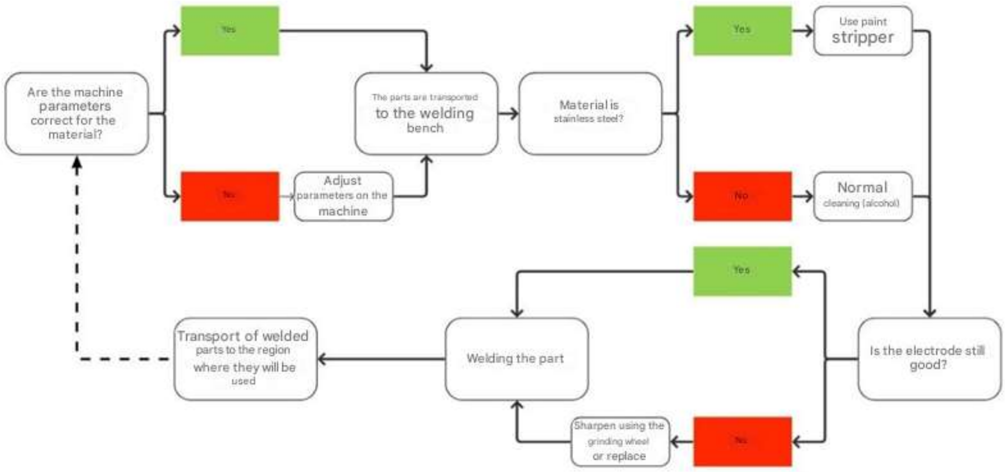

Figure 4: Flow chart of the soldering process.

The total time for the completion of the welding of the ten specimens was about 2 hours. During this period, it is necessary to change the parameters of the machine and change an electrode, taking about 2 minutes. The total time spent cleaning the parts is about 10 minutes, and the welding process takes about 10 minutes per part. After welding, there is a break of at least one hour before the operator returns to welding.

During the activities, the operator uses PPE for protection during the process: welding coat; welding gloves; auto-darkening welding mask; covered footwear and pants with low flammable material; if stripping is performed, respirator.

Using the OWAS *checklist*, it was found that the back is tilted for 89% (Figure 5) of the work time performed at the station, and it was the most critical point pointed out by the *checklist*, presenting category 3, "corrections are needed as soon as possible".

Figure 5 - Result of the *OWAS* checklist.

The results of the *OCRA checklist* indicate that the work performed by the operator's left, the side that holds the welding torch, presented a medium potential for illness, due to the worse posture of the torch arm, which needs to be positioned in order to maintain the welding quality throughout the process. From the TLV HAL method, it was found that the high level of activity of the hands, especially the hand responsible for the torch, makes it necessary to change the workstation because it presents the action level 0.56 and limit value 0.78 for the left hand.

The RULA method, responsible for assessing efforts related to the upper body, was applied to the welding activity, and reached the final score of 7, a result related to the highest possible risk, requiring immediate changes. This is largely due to the operator's posture during welding: sloping back with slightly twisted trunk and neck, with unsupported arms and slightly tilted wrist to access the welding region. In addition, the operator performs the work sitting without adequate footrest.

Environmental comfort was evaluated in two areas: acoustic and luminous. A luxmeter and a sound level meter were used to take measurements, used during a period of pause in the welding activity. The results are described in Chart 1.

	Noise	**Lighting**
Result obtained	91 dB connected machines	75.64 lux
Required by the standard	Max. 85 dB	Min. 500 lux, class B

Table 1 - Measured noise and lighting results.

3.4. Ergonomic diagnostics

Based on the results presented, it was identified that the main postural problems found at the workstation are: static sitting posture with excessive back and neck inclination and for a long period, in addition to the absence of adequate support for the feet, and repetitive activity of the left hand with inadequate wrist inclination.

Although the height of the chair and table is in the appropriate range for the operator, a fine adjustment of the height is necessary, in addition to the angle of the table in order to obtain an improvement in the armrest, and to reduce the inclination of the back and neck. As for the environmental comfort variables, although the noise level only exceeds the limit of the standard when all the machines are on, which occurs infrequently, preventive measures are necessary to avoid operator discomfort. To control the weld quality, a greater amount of lighting is required on the workbench.

3.5. Ergonomic recommendations

Based on the ergonomic diagnosis, it is recommended to replace the current model of chair with a model with height adjustment and less inclination of the back support, which in the current model is unusable. For the feet, adequate support must be acquired. It is also necessary to replace the welding table with a model with height adjustment, and preferably with angle and groove adjustment to facilitate the fitting of the parts to be welded, both the table and the chair need to be made of non-flammable material. For the evaluated operator, it is advisable that the height of the table is about 820 mm, the recommended height for high-precision tasks (GRANDJEAN, 1998) and the height of the chair is about 440 mm.

When all machines are switched on, it is recommended that the operator wear a hearing protector. As the use of the welding mask can hinder the use of the shell protector, it is recommended to use an in-ear model. To increase the lighting of the countertop, it is suggested to install an adjustable lamp attached to the table, with enough luminous intensity to reach 500 lux.

4. Conclusions

Despite the low welding load of a laboratory, the nature of the activity and ergonomic risks involved are the same as those evidenced in medium to large companies. Even if the suggested ergonomic recommendations are implemented to reduce the risks identified, problems related to static sitting posture and repetitive activity should be monitored by the laboratory to monitor their long-term impacts on worker health. If the need for further interventions is ascertained, it is recommended to carry out a further study considering the frequency and duration of post-welding pauses.

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