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DESIGN OF WELDING ARMREST BASED ON ERGONOMICS ANALYSIS: CASE STUDY AT EDUCATIONAL INSTITUTION IN JOHOR BAHRU, MALAYSIA

M. S. Md Yusop[1], S. Mat[1, 2], F. R. Ramli[1, 2], A. R. Dullah[1, 2], S. N. Khalil[1, 2] and K. Case[3]
[1]Faculty of Mechanical Engineering, Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya, Durian Tunggal, Melaka, Malaysia
[2]Centre for Advanced Research on Energy, Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya, Durian Tunggal, Melaka, Malaysia
[3]School of Mechanical, Electrical and Manufacturing Engineering, Loughborough University, Epinal Way, Leicestershire LE11 3TU, United Kingdom
E-Mail: shafizal@utem.edu.my

ABSTRACT

Nowadays, many high technology machines, mechanical devices, and modern mechanical processes exist to create better products and to produce them instantly. The welding process is one of the mechanical processes to produce a product, and it requires the welder to stay in a static posture for long period of time. Due to this problem, the process is seen to be unsafe and unhealthy to the welder. This study focuses on students who perform welding activities in the welding workshop of an educational institution in Johor Bahru, Malaysia. The aims of this study were to propose a design to improve the welding process and reduce the ergonomics problem. The study used Rapid Upper Limb Assessment (RULA) analysis to analyze the posture of students during the welding process. The RULA analysis and proposed design were performed using CATIA V5R19 software. The results show that the proposed design gave better results which reduced the RULA score from 6 to 2 while the color turned from orange to green (acceptable position).

Keywords: welding, posture, ergonomics, welding armrest, rapid upper limb assessment (RULA).

INTRODUCTION

Mechanical engineering is one of the most important sectors over the past few centuries. Nowadays, many high technology machines, mechanical devices, and modern mechanical processes exist to create better products and to produce them instantly. One of the mechanical processes for producing products is the welding process. Welding is a process to join two or more metals by using a welding machine and tools. The joining can use arc welding (SMAW), gas metal arc welding (GMAW), tungsten inert gas (GTAW) and oxy acetylene welding (gas). The welding process requires a welder to stay in a static posture for a long period of time. This static posture can cause muscle pain to the welder, creating an ergonomics problem due to the working style. At an educational institution in Johor Bahru, mechanical engineering students need to learn welding processes involving all types of welding such as SMAW, GMAW, GTAW and gas.

The study focuses on the welding processes in the welding workshop of an educational institution in Johor Bahru where welding is performed by students. The welding activity cannot be separated from ergonomics since it involves the posture of the welder. Based on verbal interviews, most of the students said that the problems that occur during the welding process include lack of experience, unfamiliarity with the process, hand shiver due to the static posture and muscle pain due to the weight and long welding time. Students need to bend their body and hold the welding tools during welding processes. These conditions result in increased work load compared to the usual condition. These unsafe and unhealthy conditions will affect the comfort and cause musculoskeletal disorder in the students (Ruliati *et al.,* 2015). The position of the students during welding is ergonomically unsatisfactory and if continued repeatedly, can cause muscle and back pain. Even though it purpose is for learning only, when it comes to doing a project, the students need to stay in one position for a long time and thus it causes fatigue and musculoskeletal disorders. Due to these problems, it is necessary to make improvements to the welding activity in terms of ergonomics in order to prevent and reduce musculoskeletal disorders and risk of fatigue in the students (Ruliati *et al.,* 2015).

LITERATURE REVIEW

Ergonomics plays important roles in industry to improve safety and health of the human body. It is related to the worker in the workplace. The ergonomics objective is to fit machine and man together to improve the performance of the worker, reduce risk, stresses and fatigue at workplace (Kushwaha and Kane, 2015). The ergonomics issues are always related to the workplace and workplaces that have ergonomics problems can harm humans for example through muscle pain and even worse; accidents. According to the statistics, about 44 million workers in Europe suffered from the occupational musculoskeletal disorder (Otto and Battaia, 2017). This shows that the ergonomics problem is a major issue that needs to be solved to avoid further suffering in the future.

This is also applied to the educational institution where students learn in the workshop. Students are also exposed to the ergonomics problem while learning or doing practical work in the workshop. This study focuses on the welding workshop where the students need to learn how to use tools and welding machines to perform a task.

During welding, students need to hold the welding tools in a standing position because it is easy to move and has a large degree of freedom. But, when the students spend a long period of time in the standing position while performing the task, they may feel uncomfortable, tired and experience muscle fatigue at the end of the task (Ismail *et al*., 2015).

The most common types of ergonomics injuries and illness are musculoskeletal disorders (MSDs) (Ismail *et al*., 2015). MSDs are injuries of the human body that especially affect spinal tendons, muscle, ligaments and nerves. It is a major problem in ergonomics which can cause permanent disability. With planning and controlling how the work is done, it can be possible to achieve the goals and objectives without any problems (Yusop, 2010). The planning of how the work is performed can affect the human body while working, and needs to be done correctly to avoid any injuries to the human in the workplace.

The Rapid Upper Limb Assessment (RULA) method was developed by Dr. Lynn McAtamney and Prof. E. Nigel Corlett. It is a tool which allows the evaluation of the loads sustained by the muscle-skeletal system due to work posture, muscle use; force exerted and can calculate the exposure to risk factors associated with work-related upper limb disorder (McAtamney and Corlett, 1993). RULA produces a score to demonstrate the risk level of a posture (Zein *et al.,* 2015; Godilano and Villanueva, 2015). The scores are divided into 4 levels which are 1 or 2, 3 or 4, 5 or 6 and >7. Score 1 or 2 indicates an acceptable posture where the posture does not have any ergonomics problem. The other scores require further investigation (3 or 4), changes require soon (5 or 6) or changes required immediately (>7). RULA could be a quick observation method of posture analysis (Dockrell *et al*., 2012). It is one of the methods that provides posture data of the human body during a working period. Originally, a RULA evaluation was carried out using a RULA employee assessment worksheet that was completed manually by interviewing the worker. Now, RULA method can be done by using computer software that automatically calculates the posture of the human body (Mat *et al.,* 2017). This can reduce time and cost because the design can be done in the software and there is no need to produce a prototype.

METHODOLOGY

Generating idea

The welding workshop at an education institution in Johor Bahru, Malaysia provides a place for students to perform welding tasks as shown in Figure-1. Basically, students perform the welding activity on the provided platform. There are two positions possible during welding activity, a standing position or a sitting position. To perform the welding activity at the chosen welding workstation, students need to stand and bend a little to reach the welding platform. During observation, the students were seen to be uncomfortable with the posture and this affected the performance of the welding outputs. This is because the existing posture needs the students to hold welding tools in their hand for a long time without any arm support.

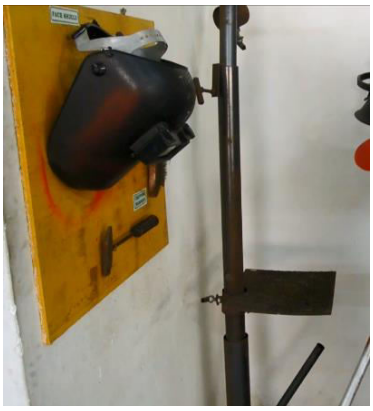

Figure-1. Welding workshop.

Existing design and current posture

Based on the existing layout of the welding workshop, the equipment to perform the welding activity is a platform stand. To design the platform stand there is a need to study the actual posture of the students. The actual shape and dimensions of the platform stand were measured. A typical actual posture of a student during the welding activity is shown in Figure-2(a). The measured dimensions were then transferred to the CAD software to visualize the actual geometry of the layout. The posture of the student was copied and created in the ergonomics software to study the posture as shown in Figure-2(b).

(a) Current welding posture (actual) (b) Current welding posture (ergonomics software)

Figure-2. Welding posture.

Proposed design and new posture

The proposed design includes a welding armrest that is to be designed by using CATIA V5R19 software. The dimensions of the design were measured according to the manikin that was created in the ergonomics software to

ensure the accuracy of the analysis. The proposed armrest can be rotated 360 degrees to left and right for the comfort of the welder. Also, the armrest can move forwards and backwards for easy of handling during the welding activity. Figure-3 shows the proposed welding armrest design.

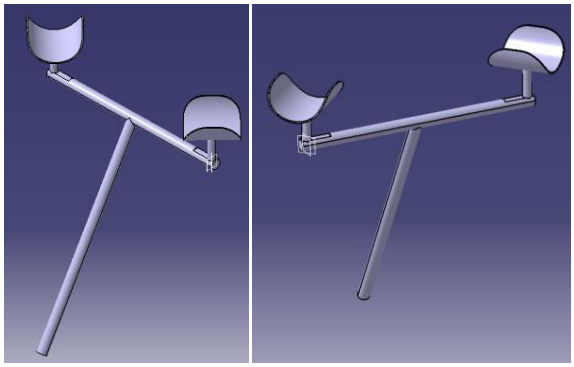

Figure-3. Proposed design (Welding Armrest).

To study the posture of the students using proposed welding armrest design, the prototype was fabricated to the actual dimensions. The fabricated prototype had the same function as the proposed design with two arm supports that can rotate and are adjustable according to the height of the student. Figure-4(a) shows the posture of the student while performing welding activity by using prototype model. The posture is the same with the current posture but the difference is that both of the student's arms are supported during the welding activity. This results in reduced load exerted by the student and also can solve back pain. The new posture of the student using the proposed design is shown in Figure-4(b) where the actual posture was copied into the ergonomics software.

(a) New posture using actual model

(b) New posture using prototype model (ergonomics software)

Figure-4. New posture.

RESULTS AND DISCUSSIONS

The ergonomics analysis is used to validate the ergonomics data on the current and new posture of the student. The ergonomics analysis used in this study was RULA which stands for Rapid Upper Limb Assessment analysis and is used to investigate the postures of humans that are exposed to the risk of upper limb disorders (Mat *et al*., 2011). RULA analysis was carried out using CATIA V5R19 software. The design and analysis can be done simultaneously in the software. RULA examines several risk factors of human body posture, loads, muscle and calculates these factors into a human posture score. The RULA analysis result is based on the score and color. The score and color are related to each other. There are 7 scores and 4 colors. The colors are green, yellow, orange and red. The green color indicates that the posture is good while red color indicates that the posture is bad and needs to be changed immediately. The scores are divided into four scales where each scale has its own description. Table 1 shows the description of each scale in RULA analysis.

Table-1. RULA analysis score description (McAtamney and Corlett, 1993).

Level	Score	Description
1	1 or 2	Acceptable posture if not maintained or repeated for long periods
2	3 or 4	Further investigation needed and may require changes
3	5 or 6	Investigation and changes required soon
4	> 7	Investigation and changes required immediately

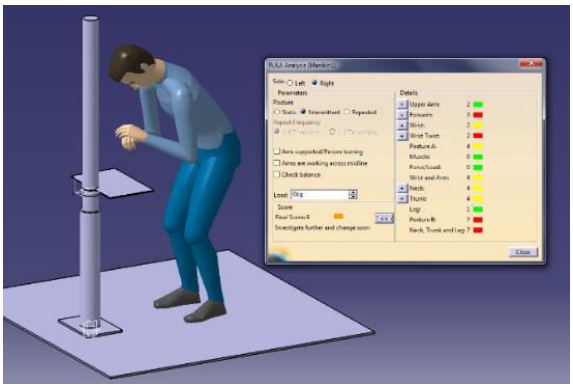

Figure-5. Current posture of student using existing design.

Based on Figure-5, current posture requires the student to stand and slightly bend to perform the welding activity. Also, both arms are hanging and can cause muscle pain and fatigue. According to the current posture, the students not only feel uncomfortable during welding but it also resulted in a bad weld because the student cannot maintain the same posture during the welding.

Figure-6 shows the result of RULA analysis using CATIA V5R19 software. The results show that several human body parts have a high score with score of 7 at the neck, trunk and leg. Also, it shows the red color indicating high risk. Other parts are forearm and wrist that

have red color and need to be changed immediately. The posture is set to be intermittent with a final score of 6. The final score shows the orange color and the advice is that it should be investigated further and changed soon.

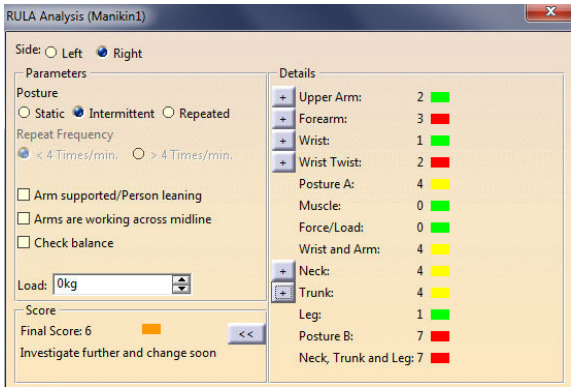

Figure-6. Result of RULA analysis for current posture.

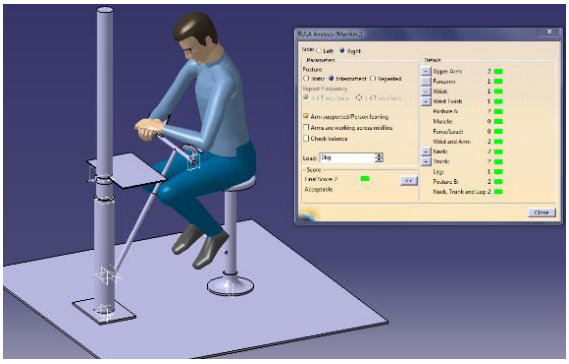

Figure-7. New posture of student using proposed design.

Figure-7 shows the new posture of the student during welding activity. The student can use a chair to perform the welding activity since the arm is supported by the welding armrest. The majority of the load of the body is transferred to the arms where both arms are supported by the welding armrest. The student can rest and use less load during the welding activity.

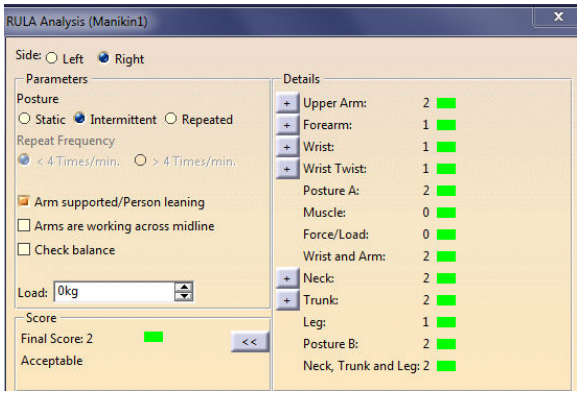

Figure-8. Result of RULA analysis for new posture.

The result of RULA analysis for the new posture in Figure-8 shows an improvement compared to the current posture using the existing design. Most of the parts of human body have a lower score which between 0 and 2. Also, the color shown is green indicating the posture is at lower risk. The posture was set to be intermittent with arm supported. The final score is 2 and the posture is considered as acceptable. This result shows the student does not have ergonomics problems while performing welding activity using the welding armrest. It can be confidently assumed that the proposed design which is welding armrest is successful to eliminate the ergonomics risk experienced by the student.

CONCLUSIONS

It can be concluded that it is important that the posture of the human body be analyzed using an ergonomics approach to avoid any injuries and illness. This not only involves the worker at the workplace but also it applies to the student performing a task in the workshop. Based on the results using RULA analysis, it was shown that the proposed design gives a better result where the final score was reduced from 6 to 2 while the color turns from orange to green. The proposed design has changed the student posture, reducing muscle pain and fatigue. It can also be concluded that the proposed design (welding armrest) using ergonomics approach reduces fatigue and musculoskeletal disorders. Also of importance is that the student can perform welding activities with comfort and safety and thus produce better welding results.

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