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DESIGN WORK STATION OF PIPE WELDING WITH ERGONOMIC APPROACH

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Abstract --*The activity of welding specimens on a big pipe that causes various problems for the body, in this activity the worker is at a risky position such as lifting a pipe weight 90 kg, lifting the specimen and welding the pipe with the specimen and the final process is to lower the pipe that has been connected. The purpose of this study is to design workstation by the principles of ergonomics to help reduce physical worker complaints. The research method in this study was the Nordic Body Map (NBM) questionnaire to determine complaints of musculoskeletal disorders (MSDs); the work posture was analyzed by the Rapid Entire Body Assessment (REBA) method. From the results of this study, it can be concluded that the welding work requires a tool in the form of a bench, pipe support, a pulley used at a new welding workstation. With a new workstation, poor work posture can be repaired. With a new work station, there is an efficiency of 8.33 minutes of work time from previous working conditions.*

Keywords*: Pipe Welding; MSDs; NBM; REBA*

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INTRODUCTION

The basic premise of ergonomics is that job demands should not exceed workers' capabilities and limitations to ensure that they would not be exposed to work stresses that can adversely affect safety and health as well as the company's productivity (Mansor et al., 2014; Jaffar et al., 2011). Working conditions assessment showed that the main ergonomic problems in the workshops studied originated from awkward working posture, improper workstation design, poorly designed hand tools and incorrect manual material handling (Nodooshan et al., 2016). The productivity of worker much depends upon the ergonomic design of workstations. Efficient ergonomics in workstation design shows better interaction between man-machine systems. A lot of research has been done on analyzing and improving ergonomics of workstation, facility layout, and tool design (Mali & Vyavahare, 2015).

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 a long period of time (Md Yusop et al., 2018). In welding operation, physical dimensions of the workstation are of significant influence from the viewpoint of production efficiency and operator's physical and mental well-being. The physical dimensions in the design of an industrial workstation are of significant importance for perspective of production efficiency and occupational health and safety (Brito et al., 2017). Rae & Easson (1995) stated some of the factors that require consideration when analyzing and designing the welding environment to include physical ability of the worker, weight of the gun, design tools, body mechanics during welding, type of protective equipment in use, workspace, and physical requirement of the job and position of the work. The types of work that is physical if done in ways that are not right, then slowly can cause complaints of muscular skeletons (musculoskeletal disorder). If this is not handled seriously, it can cause more severe consequences. Since a strong relationship exists between other occupational risk factors and work posture, there is a need to assess how they interact intending to raise productivity (Torik, 2017).

The activity of welding specimens on a big pipe that causes various problems for the body, including muscle pain in the neck, arms, waist, and legs. In this activity the worker is at a risky position such as lifting a pipe weighing 90 kg, lifting the specimen and welding the pipe with the specimen and the final process is to lower the pipe that has been connected. The following is an illustration of the pipe welding process carried out can be seen in Fig. 1.

Figure 1. Illustration of Pipe Welding Process

Based on Fig. 1, it can be seen that the postures have risks that are quite dangerous for health, so this activity needs attention. Workers need a range of 75-90 minutes to complete welding one pipe, while the result of a bad position causes workers to need an additional resting interval of around 10-15 minutes. This condition takes a lot of time for additional breaks required by workers in addition to cracks that have been determined by the company. For the bad condition of the posture, workers do not apply their full efforts to their work, which results in lower productivity (Rahman et al., 2015). To optimize the workforce, what needs to be considered is the human aspect so that alternatives are needed, which include designing the layout of work equipment and work facilities that support workers so that they do their work regularly without causing significant fatigue (Husein, 2009). This work requires change work postures to be more secure and ergonomic. Therefore, the purpose of this study is to design workstation following the principles of ergonomics to help reduce physical worker complaints.

METHOD

The research was conducted at pipe welding workshop begins the body map questionnaire, a questionnaire Nordic Body Map (NBM) to determine the complaints of musculoskeletal disorders (MSDs) (Fajariani, Ardyanto & Basuki, 2013).

Then the work posture is analyzed by the Rapid Entire Body Assessment (REBA) method. The REBA method is recommended to verify the effectiveness of the changes (Lasota, 2014). After discovering the cause of the problem along with physical complaints, and then redesigned the welding workplace.

RESULTS AND DISCUSSION

The welding process starts with taking a pipe which is then lifted and placed into a tool, and then the worker receives the specimen to be lifted and also puts it on both sides of the pipe. The next step is to measure the pipe again to check whether it is per the specifications and small welding is done to connect the specimen with the pipe. After that, the pipe will be welded thoroughly and will be lowered and put into storage. The time needed for workers to complete one cycle of work ranges from 5220 seconds (87 minutes).

Rapid Entire Body Assessment (REBA)

REBA is a common tool used to facilitate the measurement and evaluation of the risks associated with working postures as a part of the ergonomic workload (Schwartz et al., 2019). Based on the photo of work posture, REBA analysis was carried out for each pipe welding work posture. For example, measurements using REBA on the work posture of taking a pipe can be seen in Fig. 2 and Fig. 3.

Figure 2. Workers Take a Pipe

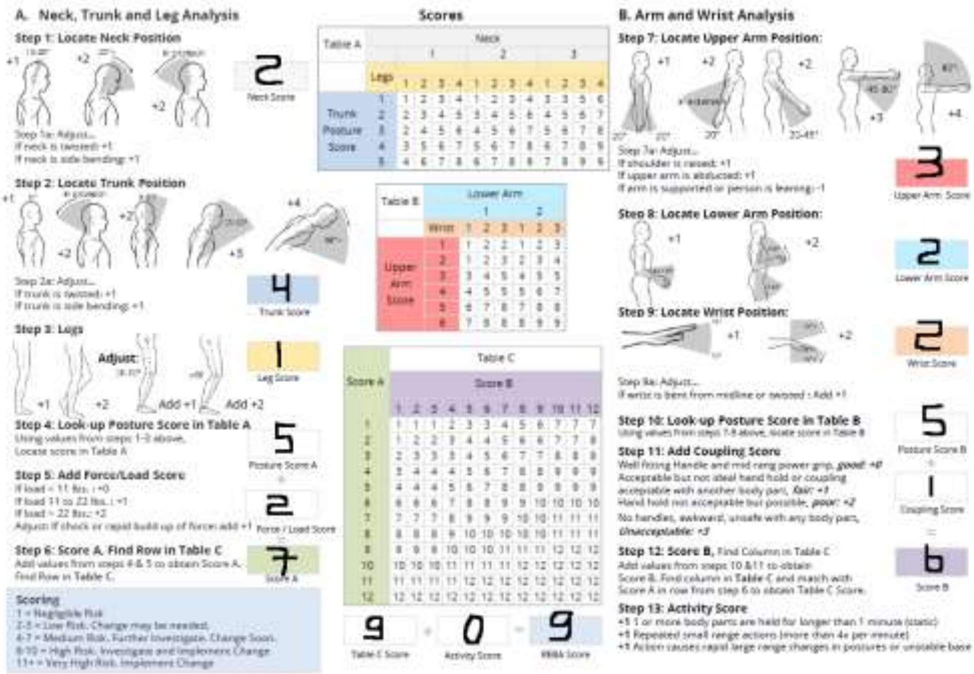


Figure 3. REBA Worksheet for the work posture taking a Pipe

Fig. 3 is a posture analysis of the workers. Eleven work postures are analyzed starting from the process of lifting the pipe, welding to lowering the pipe. Worker activity, along with the REBA value, can be seen in Table 1.

Physical Complaint Analysis of Welding Workers

Physical complaints analysis that can be considered work posture performed by workers. Musculoskeletal complaints are one of the most prevalent occupational problems (Andersen et al., 2007; Janwantanakul et al., 2008) and also contribute to an economic burden in terms of direct medical costs, loss of work productivity, work disability, absenteeism and presenteeism (loss of productivity while at work) (Bevan 2015; Buchbinder et al., 2013; CDC, 2013; Lambeek et al., 2011). The whole body parts analyzed, 11 were the highest physical complaints supported by officers from the NBM. The following are the parts of workers that can be seen in Table 2.

Complaints obtained from the NBM questionnaire were then investigated to produce workplace welding design characteristics as listed in Table 3.

Based on Analysis of Complaints, Expectations, Needs, and the Nordic body map questionnaire resulted in the design of the pipe welding work station, as shown in Fig. 4. For the bench design on the welding work station, it is adjusted to the worker anthropometric data, as shown in Fig. 5.

Table 1. REBA Results for All Work Posture on Pipe Welding Activities

Activities	REBA Score	Risk level	Analysis
Taking a pipe	9	High Risk	There needs to be an investigation and implementation of change
Lifting Pipe	5	Medium Risk	There needs to be further investigation and change as soon as possible
Putting Pipe	6	Medium Risk	There needs to be further investigation and change as soon as possible
Taking specimens	9	High Risk	There needs to be an investigation and implementation of changes
Lifting Specimens	5	Medium Risk	There needs to be further investigation and change as soon as possible
Putting specimens	8	High Risk	There needs to be an investigation and implementation of change
Welding	8	High Risk	There needs to be an investigation and implementation of change
Rotating	9	High Risk	There needs to be an investigation and implementation of change
Taking finished goods	9	High Risk	There needs to be an investigation and implementation of change
Lifting Finished Goods	7	Medium Risk	There needs to be further investigation and change as soon as possible
Putting Objects	4	Medium Risk	Put Finished Goods Need further investigation and change as soon as possible

Table 2. Analysis of Physical Complaints and their Causes

Physical complaints	Analysis of the Causes of Complaints
Pain in the upper neck	Complaints on the neck due to workers doing their work with a state of bowing down in a long enough time when welding takes place, as evidenced by a bad REBA posture.
Pain in the right and left shoulder	Workers are in a bent position while doing the welding process for a long time causing the shoulder to be in a bent position so that the shoulders get tired faster, as evidenced by the bad REBA posture.
Pain in the upper and lower waist	Welding tools that have a position that is too low and the absence of a chair causes the worker to bend over a considerable time and cause the waist to be attracted, as evidenced by a bad REBA posture.
Pain in the left and right thigh, the left and right knee, the left and right calf	During the welding process workers do not have seats to support their weight, so workers have to squat and cause the workers' legs to bend too long, evidenced by the bad REBA posture.

Table 3. Analysis of Complaints, Expectations, Needs, and Design

Complaint	Expectation	Needs	Design
Muscle pain in body parts such as the neck, shoulders, and waist due to poor work posture	Workers do not do work in a bent posture for a long time	Higher placement of workpieces so that it can improve work posture and reduce complaints of muscle pain	The design of this tool is adapted to the anthropometry of workers so that the work posture becomes more ergonomic and reduces bending posture
Muscle pain in body parts such as the waist, thighs, knees, and calves due to a squat work posture	use a bench to support your body weight, so worker don't squat	The bench that helps support body weight, so workers do not have to work in a squat position	The design of the tool is adapted to the worker anthropometry to make it more comfortable and complaints less
lifting a heavy pipe cause muscle injury	Workers do not carry too weight pipe	A work tool that helps reduce pipe lifting that is too heavy	Design of pipe lifting tools
The process of turning heavy workpieces during welding	Workers can rotate workpieces during the welding process easily	A tool to rotate the workpiece, so it is light when rotated	Design a machine using a roller to help ease the rotating process

Table 4. Results of the Current Work Posture Assessment and Welding Work Station Design with the REBA Method

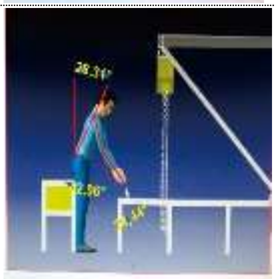
Activity	Current Work Posture	REBA Score	Tool Design	Activity	REBA Score
Taking a pipe		9		Hang a rope to lift s	4
Lifting Pipe		5		Pull the pulley to lift the specimen	1
Put Pipe		6		Put the pipe into the aid	3
Lifting Specimens		5		Put the specimens to be welding	2
Weld		8		Do welding	3
Rotate		9		Rotate the specimen	3

Figure 4. Work Station Designs

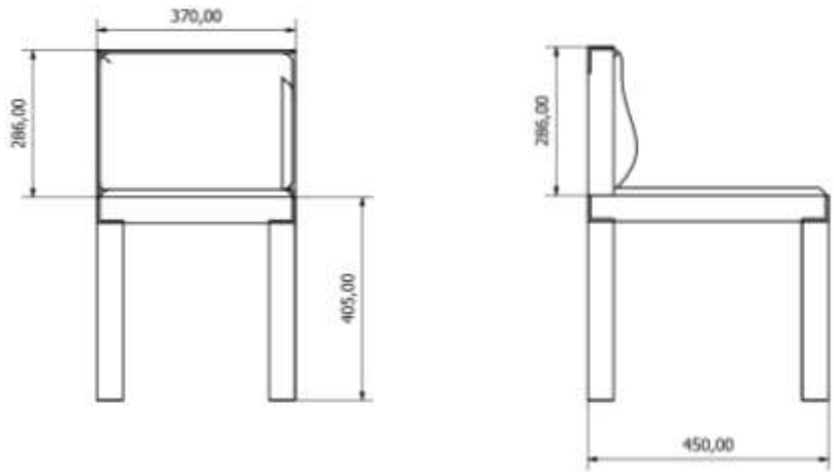


Figure 5. Bench Design at a Welding Station

Posture analysis work with the REBA method

The design of the selected welding work station is simulated using CATIA software. The results of the design simulation are compared with existing working conditions, and work posture assessments are carried out using the REBA method, as shown in Table 4.

The following is a bench; pipe support and work station of pipe welding that has been developed, as shown in Fig. 6, Fig. 7, and Fig. 8.

Figure 6. Bench for welding

Figure 7. Pipe Support

Figure 8. The workstation of Pipe Welding

The time needed for workers to complete one work cycle using a new workstation is 4720 seconds (78.67 minutes) with a break time of 360 seconds for breaks per work cycle, this time is shorter than the previous work time of 5220 seconds (87 minutes). There is an efficiency of 8.33 minutes of work time. This condition means that a good work posture can reduce work fatigue and increase productivity.

CONCLUSION

Based on results founded of this study, it can be concluded that welding work requires tools such as benches, pipe supports, and pulleys used in new welding stations by adjusting the body posture of the worker. With a new welding workstation, poor working posture can be improved and can reduce the power in lifting pipes and specimens. By comparing the old work station with the new work station, there is a decrease in work time of 8.33 minutes, so that it can increase the number of products produced in one day.

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