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Development of Arc Welding Training Aid for Padding Training

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Abstract: This study is to develop Arc Welding Training Aid For Padding Training. The design of the study is product development and identification of product suitability as a training aid. The Hanaffin & Peck model is used as a guide in developing products as the training aid. The data obtained were analyzed using frequency and percentage descriptive data to see if the training aid produced could be used for practical learning. The findings show the high value of training aid usage. Expert confirmation was 3 people consisting of 2 lecturers and a technician. It can be concluded that the design of Arc Welding Training Aid For Padding Training is suitable as a tool used in practical learning and specifically in padding training to help students learn to control three welding processes namely arc distance, electrode angle and electrode movement speed for the subject of metal fabrication skills at UTHM.

Keywords: Teaching Aid, Arc Welding, Padding

1. Introduction

The thriving country of Malaysia represents the educational revolution of today. The various challenges that need to be addressed, especially vocational education that will give rise to highly skilled individuals in the pursuit of industry skills, with the aim of improving the standard of living and economy of the country, hence the challenges faced in technical and vocational training today, is to produce skilled and semi-skilled workers in engineering especially welding related to the study of authors.

According to Syed Jaafar (2014), competence is the ability of a person skilled in their field to perform a task responsibly and effectively and efficiently. However, competency among students cannot be achieved because there are weaknesses among the students in welding skills which is the result of welding done by students who do not meet the requirements set out by the American Welding Society (AWS). The problem that students have with welding skills is that they are difficult to produce neat bead properly and according to AWS guidelines, there are deficiencies in the bead that was produced by students. According to Putut Hargiyarto (2014), the error in performing welding

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procedures in accordance with AWS guidelines causes the resulting bead to have defects. This problem causes students to score poorly in the visual assessment done by the lecturer.According to Zulhusni (2018), the work of welding that does not meet the requirements causes students to fail to obtain high marks to qualify them as competent welders. Welding training requires continuous and frequent training, this allows welders to master the correct welding techniques and procedures. This is supported by Laurent de Daito (2009) who states that continuous training is essential for welders to find the right technique to produce a good and perfect bead. Researchers interviewed a lecturer of Metal Fabrication Skills subject in the Faculty of Technical & Vocational Education (FPTV) at Universiti Tun Hussein Onn Malaysia (UTHM) for more information. Kamarul (2012), stated that the method of in-depth interviews was to obtain detailed information from a respondent-based on the questions or guidelines that the researcher had formulated.

Based on observations by the lecturer of the metal fabrication skills subject, in terms of visual inspection of the work by welding students, he noted that there was a defect on the bead. He also showed the mark that students get by his visual inspection. According to Iezan Rashid (2016) visual inspection is one of the ways to identify defects in the bead as well as to give marks to students. As a result, 30 percent of students scored low marks due to poor welding and maximum defects. His statement is in line with Zulhusni (2018) which states that students score low due to a defect on the bead that traces by visual inspection on the work of welding students. He also noted that students with welding problems were from students who had no experience in welding skills before they entered the training center and that they could not master welding procedures properly. This statement is in line with the study of Mutim (2017), which states that ninety-seven percent of students have no experience in the welding process before entering welding skills centers. Based on the interviews conducted, in addition to inexperienced factors, the main factor is that students are not able to master the procedure while properly welding. Based on the statements stated in the above article, the factors that lead to defective production are due to weaknesses in adherence to welding procedures. According to Duane (1997) the factor that causes defects in the result of students' welding process is that they do not master the welding process properly. One such procedure is to maintain the proper arc distance that the student cannot control.

According to the book entitled Basic Welding Technical Learning College (2018) new trainers who learn welding skills have difficulty maintaining the arc distance. The effects of unprotected arc distances can result in serious defects on the surface of the bead, defects such as undercut, crack and space. According to the book entitled The ABC of Arc Welding and Inspection (2015) the appropriate arc distance between the ends of the electrode and the metal surface is the same as the electrode diameter if the distances are too close to the recommended distance, undercut defects will occur. One of the reasons students are not able to control the arc distances is due to their poor visibility and the students are unable to control the arc distance between the ends of the electrode and the metal surface. According to Finbar Smith (2014) the use of a face mask with dark glass to protect the welders' eyes from bright light caused the students to not see the arc distance between the tip of the electrode and the metal surface, resulting in defects such as height and width of the bead. Therefore, teachers need to find a solution to help students control the arc distance. Next, the second factor is that students cannot control the angle of the electrode correctly during welding. According to Duane (1997) the bead does not meet the connection space due to the angle of the electrode which does not meet the Welding Procedure Specification (WPS) recommendation. The angle hold of the electrode by the student is less than that of the WPS recommendation, resulting in an arc not concentrated in the welding area. According to the book entitled Basic Welding Technical Learning College (2018) to ensure the arc is in the correct space, the appropriate electrode angle is 70 ° to 60 °. Properly positioned electrodes will create a strong and lasting connection to the workpiece. Emphasis on the angle of the electrode during the welding process should be taken into account in order for the perfect and quality welding to be formed on the connection (Finbar Smith, 2014). Keeping the right angle of the electrode during the welding process difficult for students as the hands are free to hold without making it difficult to maintain the correct electrode angle. This is in line with Alex (2014), who states that the welding arm hanging without restraint will cause the welding arm to swell and have the effect of maintaining the correct electrode angle in the welding process. Steps need to be taken to help students get used to it and to keep their hands from getting tired during welding.

Students are unable to control the speed of electrode movement as well as factors in the production of defective tissue. According to the book entitled Maritime Welding Handbook (2009) if the speed of electrode movement is too slow, the width of the bead may be too thick and cause cracking defects in the resulting bead. The rapid movement of the electrode will cause the resulting arc to not fill the connection space and the resulting bead is not straight (Alex, 2014). He also said that students who are unfamiliar with the welding process will feel flutter and cause them to want to quickly complete the welding process until they lose their control over the speed of electrode movement. Students need to familiarize themselves with the spark of fire to eliminate the tremors during the welding process to help them control the speed of electrode movement. Therefore, to address the factors that contribute to students' failure to produce neat bead, the researchers will develop the Training Aid Arc Welding for Padding Training to help students master three welding processes to obtain good welding results and to master correct welding technique. This training aid design will be used in padding training to train and familiarize students to control the welding procedure, namely arc distance, electrode angle and electrode movement speed.

2. Methodology

The design of this study was based on a quantitative approach using the survey method. The survey method used in this study was to use questionnaire instruments. Questionnaire items in this study were measured using The Guttman Scale, in the form of checklists that are answered in the form of choices like 'Yes' and 'No. In this study, the respondent is focused on lecturers and welding technicians at UTHM, Faculty of Technical and Vocational Education as well as lecturers from the Pasir Gudang ILP.

The selected study sample has the expertise and experience in welding to evaluate the product developed by the researcher. The questionnaire provided to the respondent is to obtain information related to Arc Welding Training Aid for Padding Training. This form consists of five parts, part A is the demographic review that contains 2 items, part B is a product design that contains 6 items, part C is design development that contains 5 items, part D is functionality that consist of 10 items and part E is comments and suggestions from respondents.

The problem that students have with welding skills is that they are difficult to produce well and neat bead according to the AWS guidelines. A defect in the welding results causes students to score poorly in the visual assessments of their teachers. Not mastering the welding process, maintaining the proper arc distance is a factor in the production of defect bead. Low visibility results in students being unable to control the arc distance between the ends of the electrode and the metal surface. The effects of improper arc distances can result in serious defects on the bead surface, defects such as undercut, crack and spatter. Next, the second factor is that students cannot control the angle of the electrode correctly during welding. The angle hold of the electrode by the student is less than that of the WPS recommendation, resulting in an arc not concentrated in the connection. Improper angle electrodes will result in a poorly maintained connection to the work piece.

Students are unable to control the speed of movement of the electrode and is also a factor in the production of defect bead. Inexperienced students will feel traumatized to control the proper speed during the running process. The effect is that if the speed of the electrode is too slow, the width of the bead may become too thick and cause a defect crack that resulting in the work piece. Therefore, to address the factors that contribute to the students' failure to produce good welding and free from bead defects, the researchers will develop the Arc Welding Training Aid For Padding Training for use in padding training. This training aid design will help students master the welding procedure, namely arc distance, electrode angle and electrode movement speed to obtain good welding results. The purpose of this study are to;1) Design Arc Welding Training Aid for Padding Training; 2) Develop the design of Training Aid Arc Welding for Padding Training; and 3) Test the functionality of design Arc Welding Training Aid for Padding Training.

Figure 1 shows the design of Arc welding Training Aid for Padding Training. This training aid includes 3 parts. Each part has a function for helping the student in controlling the welding procedures during the welding process.

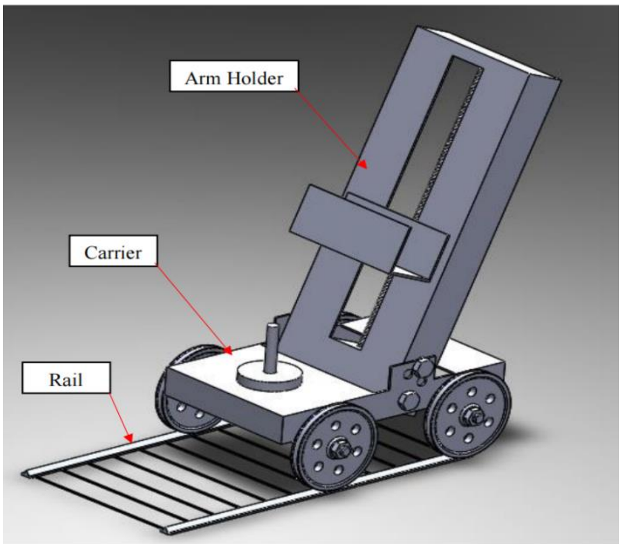

Figure 1: Design of Arc Welding Training Aid for Padding Training

The carrier part is helping students in learning to control the speed movement of electrodes. The design of the arm holder is a function to help students to learn how to control the arc distance and the angle of the electrode. for the rail, it works to ease the movement of the electrode and get a straight bead. Figure 2 shows the types of defects that occur on the bead.

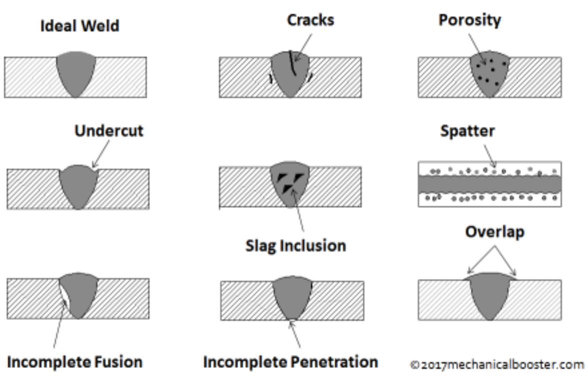

Figure 2: The types of defects that occur on the bead.

(The ABC's of arc welding and inspection, Kobe Steel, LTD, 2015)

There are nine defects that occur on the bead according to Kobe Steel, LTD. These defects because of the welding process either it is too low or too high, the speed is too fast etc.

2.1 Padding training

Padding training is one of the welding exercises to train welders to master the procedure while welding. This is supported by the Gerald Austin (2016) which states that padding training is one of the basic exercises that can improve welding skills, saving time and metal usage. Padding training is done by doing a bead stringer repeatedly on a metal plate layer by layer to thicken the metal pieces without connecting the 2 pieces of metal. In addition to this exercise, welders can practice controlling the welding procedure, namely arc distance, electrode angle and electrode movement speed.

2.2 Defects on bead

Defects on the bead are due to applying welding procedures incorrectly. According to the book entitled The ABCs of arc welding and inspection, Kobe Steel, LTD (2015) defects due to bead were made before and during welding. Table 1 shows the causes of defects on the bead and diagram 7 shows the types of defects that occur on the bead. Table 1 implied that there are seven defects that occur on the bead and also preventive measures of the defect.

Table 1: Causes of the type of defect that occurs on the bead

Kinds of welding defects	Causes of welding defects	Preventive measures
Undercut	1. An arc blow that disturbs the arc direction in DC welding. 2. Welding current is too high. 3. Welding speed is too fast. 4. Arc length is too long. 5. Electrode drag angle is too large.	1. Place the grounding at the welding-start area of the base metal. 2. Use proper welding currents. 3. Use proper welding speeds. 4. Keep arc length as short as the electrode diameter. 5. Keep electrode at a proper drag angle. (20-30 degrees)
Overlap	1. Welding current is too low. 2. Welding speed is too low. 3. Arc length is too short. 4. Electrode drag angle is too small.	1. Use proper welding currents. 2. Use proper welding speeds. 3. Keep arc length as short as the electrode diameter. 4. Keep electrode at a proper drag angle (20-30 degrees).
Porosity including pits and blowholes	1. Welding groove is contaminated with rust, oil, paint or moisture. 2. Electrode covering picks up a large amount of moisture.	1. Remove dirt in the welding groove by using a grinder, gas flame, or wire brush. 2. Redry covered electrodes before use.
Slag inclusions	1. Weaving width is too much. 2. Welding current is too low. 3. Slag that remains in the preceding layers. 4. Welding groove is too narrow. 5. Base metal is inclined downward to welding direction in the flat position.	1. Use proper weaving widths up to three times the electrode diameter. 2. Use proper welding currents. 3. Remove slag completely. 4. Prepare the welding groove with a proper width. 5. Keep base metal horizontally or use higher welding speeds, using a higher current.
Incomplete fusion	1. Welding current is too low. 2. Welding speed is too fast. 3. Arc voltage is too high. 4. Welding groove is too narrow.	1. Use proper welding currents. 2. Use proper welding speeds. 3. Keep arc length as short as the electrode diameter. 4. Prepare the welding groove with a proper width.

Cold cracks (Mostly transverse cracks, toe cracks, root cracks, and underbed cracks, but possibly longitudinal cracks)	1. Electrode covering that picks up a large amount of moisture. 2. Cooling speed of the weld is too fast.	1. Redry covered electrodes before use. 2. Preheat base metal.
Hot cracks (Mostly longitudinal cracks, crater cracks and sulfur cracks, but possibly transverse cracks)	1. Welding current is too high. 2. Welding groove is too narrow.	1. Use proper welding currents. 2. Prepare the welding groove with a proper width.

3. Results and Discussion

The researcher uses descriptive statistical methods to obtain the data obtained from the respondents and processed, analyzed and evaluated by frequency and percentage method. Through the data obtained, the researcher can determine whether the module developed has reached its objective and can answer the research question. This demographic analysis is to find out the background of the respondents in terms of welding experience and professional certification in welding they have. Respondents' background is important in this study as it can classify the individuals involved in the study. This demographic information is selected in accordance with the purpose of the study to ensure that the data obtained is relevant. Table 2 shows the analysis of frequency distribution and percentage of respondents based on welding experience.

Table 2: Analysis of frequency distribution and percentage of respondents based on Welding Experience

Demographic		Frequency	Percentage
Item 1: Experience in welding field	1-2 Years	0	0%
	3-4 Years	0	0%
	5-6 Years	1	33%
	7-8 Years	2	67%
	9-10 Years and above	0	0%

The lecturer and technician of FPTV, UTHM has 7 - 8 years of experience (67%). Meanwhile, another teaching staff from Pasir Gudang ILP has 5 – 6 years of experience (33%). Table 3 illustrates the professional certificate analysis in welding field.

Table 3: Professional certificate analysis in welding field

Demographic	Respondent	Professional cert
Item 2: Professional cert in welding field	1	Cswip, 6G
	2	Cswip, 6G
	3	SKM 5 for arc and gas welding, 6G

From Table 3 showing that the selected respondents have a professional certificate in welding, respondents 1 and 2 have expertise in Certification Scheme for Welding Inspection Personnel (CSWIP), respondent 3 has a Level 5 Malaysian Skills Certificate (SKM 5) in arc welding and gas welding. The table also shows that all respondents had expertise in 6G welding position.. Table 4 elaborates on the analysis of percentage distribution of ratings for teaching aid design aspects.

Table 4: Analysis of percentage distribution of ratings for teaching aid design aspects.

No.	Item	Expert			Total of agreement	Percentage
		1	2	3		
1.	This teaching aid design suitable for users?	/	/	/	3	100%
2.	This teaching aids design suitable for use as teaching aid in practical work?		/	/	2	67%
3.	This teaching aid design suitable for student learning in terms of controlling the distance in practical work?	/		/	2	67%
4.	This teaching aid design suitable for students learning in terms of controlling the electrode angle in practical work?	/	/		2	67%
5.	This teaching aid design suitable for students to control the speed of electrode movement in practical work?	/	/	/	3	100%
6.	This teaching aid design suitable for padding training?	/	/	/	3	100%

Table 4 shows the percentages obtained through the design suitability assessment for teaching Aid Arc Welding For Padding Training. 6Six items were provided to the respondents. The results showed that all respondents answered 'Yes' which earns 100% for items 1, 5 and 6. They consider this teaching aid design to be user-friendly and in padding training. For items 2, 3 and 4 respondents agree 67%, that indicates this teaching aid is suitable for practical work and training in welding procedures. Table 5 shows that respondents answered 'yes' with 100% percentages for items 3 and 5, indicating that they agreed that the teaching aid design installation extension of part and size was appropriate. Whereas for items 1 and 2, 67% agreed that the component used by the researcher was in line with the teaching aid design function. For item 4, all respondents 'No' agreed that this teaching aid had other functions as stated by the researcher.

Table 5: Analysis of percentage distribution of ratings for aspects of teaching aid design development

No	Items	Expert			Total of agreement	Percentage
		1	2	3		
1.	Do the components used are suitable with the function of this teaching aid?		/	/	2	67%
2.	This teaching aid design meet the needs of students in mastering welding procedure?	/	/		2	67%
3.	Is the teaching aid installation extension design suitable?	/	/	/	3	100%
4.	Does this teaching aid design have any function other than those mentioned?				0	0%
5.	Does this teaching aid design size suitable for practical work?	/	/	/	3	100%

Overall, the results show that most respondents agreed with the design of the teaching aid because the percentage of respondents who answered 'Yes' was higher than those who answered 'No'. it proves that the teaching aid design developed is appropriate.

Table 6: Analysis of percentage distribution of ratings for aspects of teaching aid design functionality

Num	Item	Expertise			Total of agreement	Percentage
		1	2	3		
	Functionality to control arc distance					
1.	Does this teaching aid easy to handle?	/	/	/	3	100%
2.	Can this teaching aid design be used as a tool for students to learn to control arc distances during practical training?	/	/	/	3	100%
3.	Can this teaching aid design help students learn how to control the arc distance during practical training?	/	/	/	3	100%
4.	Can this teaching design help students in controlling distances?				0	0%
	Functionality to control angle of the electrode					
5.	Can this teaching aid be used as a tool for students to learn how to control the angle of the electrode during practical training?	/	/	/	3	100%
6.	Can this teaching aid assist the students to learn how to control the angle of the electrode during practical training?	/	/	/	3	100%
7.	Can this teaching aid help students overcome their weaknesses in controlling the angle of the electrode?				0	0%
	Functionally to control speed of electrode movement					
8.	Does this teaching aid be used as a tool for students to control the speed of electrode	/	/	/	3	100%
9.	Does this teaching aid help students learn to to control the speed of electrode	/	/	/	3	100%
10.	Can this teaching aid help students to overcome their weaknesses in controlling the speed of electrode movement?				0	0%

Table 6 shows that all respondents answered 'yes' with 100% percentages of all items except items 4, 7 and 10. They agree that this teaching aid can help students to learn control of welding processes, electrode distance, electrode angle and speed of electrode movement. For the items they disagree with, items 4, 8 and 11 indicate that this teaching aid does not allow students to overcome weaknesses in controlling welding procedures, electrode distance, electrode angle and electrode movement speed. Overall, the results show that most respondents agree with the teaching aid functionality because the percentage of 'Yes' answers is higher than that of 'No'. it proves that teaching aid design functionality is suitable for the development.

The development of this teaching aid arc welding will be used by students of Metal Fabrication Skill Subjects at UTHM Faculty of Technical and Vocational Education Workshop as equipment. This exercise is a tool that guides students to master the process of welding namely, the arc distance between the electrode and the workpiece, the angle of the electrode, the speed control of the movement of the electrode. Students can not only understand the basic concepts of welding well but can also produce a neat bead through padding training.

The teaching aid arc welding is a product developed specifically as equipment that can assist and facilitate teachers in guiding and delivering practical teaching sessions to students. With this teaching aid, teachers are able to more easily set up their teacher preparation and save on the time of welding training provided to students, while facilitating the work of guiding and training students in handling basic welding tasks.

4. Conclusion

The development of Teaching Aid Arc Welding for Padding Training is a great step towards helping students master the process of welding in terms of arc distance, electrode angle and electrode movement speed. In the advanced suggestions section, several suggestions are given to improve the design of the teaching aid to enhance the functionality that students can use in mastering welding skills. The design of the Teaching Aid has reached the ideal of design for development. With the development of this teaching aid design, it is hoped that in the future there will be other researchers developing teaching aid with the aim of helping students master the welding process. It is undeniable that designing a teaching aid is a challenging and time-consuming endeavor to produce a functional teaching aid. However, it has many advantages and may attract users to make this teaching a specialized tool in developing basic welding skills.

The process of developing the teaching aid is a continuous process and involves expertise from various angles. Therefore, the research conducted is a challenge to the researcher. The study conducted by researchers on teaching aid design development and functionality is expected to contribute to the students' need for a future tool that can assist in practical training. The researcher also hopes that the feedback provided will help the relevant parties, especially the teaching staff, to extend the use of teaching aid in the practical learning process.

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