Journal of Ocean, Mechanical and Aerospace
-Science and Engineering-, Vol. 31

May 30, 2016

Effect of Arc Welding Amperage on the Toughness of Low Alloy Steel

Andri Arif.Kesuma,[a,*] Rinaldi,[b] Sepfitrah,[b] and Abdul Khair. J [c]

[a)] *Mechanical Technology Laboratory, Mechanical Engineering, Universitas Riau, Indonesia*
[b)] *Mechanical Engineering, Sekolah Tinggi Teknologi Pekanbaru, Riau, Indonesia*
[c)] *Ocean and Aerospace Research Institute, Indonesia*

*Corresponding author: junaidiperu@yahoo.com

Paper History

Received: 5-May-2016
Received in revised form: 27-May-2016
Accepted: 30-May-2016

ABSTRACT

This paper is to study the effect of arc welding amperage variation on the mechanical properties by using shielded metal arc welding (SMAW) E 6013 to the joint of metal that comply with ASTM E23. In the welding joint zone is always to be concern due to fusion and heating treatment that cause the change of material properties after welding process. In order to ensure the toughness of weld joint material, so tensile and charpy test are conducted to observe the properties of weld joint material. The charpy V-notch impact indicate the increasing of heat input lead to be more brittle in the weld zone.

KEY WORDS: Shielded Metal Arc Welding (SMAW); Manual Metal Arc (MMA); Charpy V-notch

NOMENCLATURE

AWS	American Welding Society
V	Voltage, Volt
A	Amperage
α	Initial Angle of Charpy test
β	End Swing Angle of Charpy test
J	Energy unit (Joule)
L_0	Initial Length
L_1	Change of length

1.0 INTRODUCTION

Arc Welding is a part of modern welding technology which is widely used in various of engineering application such as fabrication, manufacturing and is a process of metal joint by using heating to melt the metals. The welding processes are currently used in application of engineering. Shielded Metal Arc Welding (SMAW) is known as Manual Metal Arc (MMA) welding which using an electrode that has flux around it to protect the weld puddle. In the shielded metal arc welding typically used the electrical currents range between 30 to 300 A and voltages from 15 to 45 V depending on the mechanical properties of metal, electrode types and the shape of joint.

The welding amperage is a source of heat input to melt the metal joint that results the change of metallurgical structure of material. The magnitude of welding amperage and speed of electrode to feed the heat input are important parameters in welding process in order to achieve the metal joint in accordance with joint criteria. Therefore, the control of welding amperage an speed are required in arc welding process in terms of quality control.

2.0 LITERATURE REVIEW

Parvez et al (2013) studied the effect of torch angles in gas tungsten arc welding (GTAW) of SS304 stainless steel which consists of 90^0 and 70^0 of torch angles. In this study, the arc and weld pool are solved separately. Heat flux, current and gas shear stress are determined from the steady state and are applied on the weld pool surface to analyze the weld pool shape transiently after 2 second. A comparison has been conducted between 90^0 and 70^0. The welding process is analyzed by using computer software program ANSYS CFX. The result is obtained by 70^0 torch angle provides the maximum of total heat flux.

Huanming et al (2012) conducted the experiment of arc welding dealing with arc length measured from base metal to electrode in the twin-wire GMAW welding machine. The arc shapes are observed by use of shadowgraph technique with a high-speed camera. The experiment shows the different distance of arc length. When the arcs exceed to a certain length, the electromagnetic interference between both arcs becomes very strong, so welding spatter is very serious, and the weld appearance becomes worse.

Sadiq et al (2015) studied the influence of heat on a welded joint at constant voltage of 30 volts. High-Strength Low-Alloy (HSLA) steel is used as workpiece of material and two different types of electrodes (E6013 and E7013). The welding results have revealed the variation of microstructure in the welded zones. The finest grain size has the highest tensile strength alongside with good hardness value.

Shujun et al (2011) performed an experiment that dealing with current density and arc pressure distribution during welding process. In this study, the combined measurement system of arc current and arc pressure based on the split anode method to measure the DC-TIG arc and DC-PAW arc. The distribution characteristics of the current density and arc pressure indicate that the current density and the arc pressure increase as the current increasing and the increase of the arc length, the current density and pressure in the arc center decrease.

3.0 METHODOLOGY

3.1 Flowchart

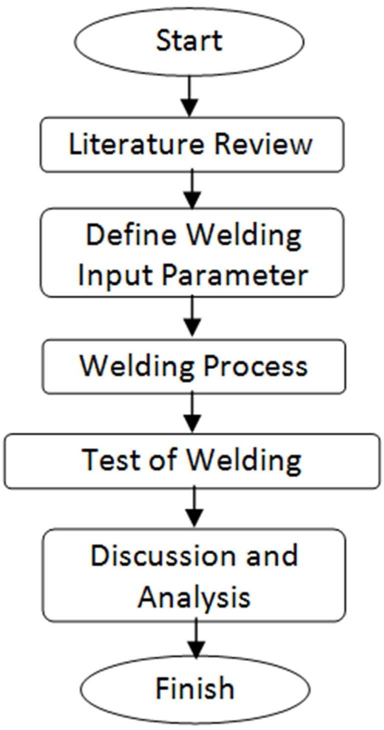

Figure 1: Flowchart of welding experiment

In the present work, the base metal consists of two plates which have the thickness of 8 mm according to ASTM E8-4 as shown in figure 2. The filler metal of E6013 is used to weld the metal joint and having single V butt joint welding type. The welding process is performed with different of welding current such as 60A, 95A and 125A. In order to study the mechanical behavior of metal joint (specimen), the tensile and impact test are conducted to analyze the effect of welding speed and amperage.

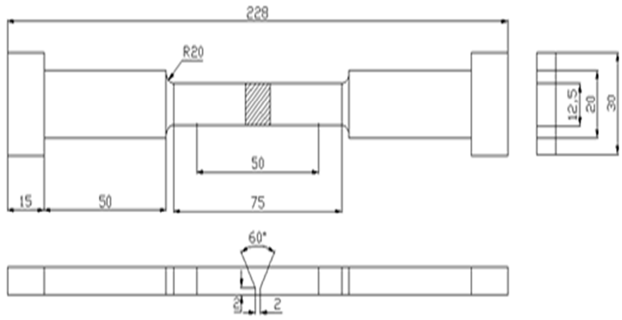

Figure 2: Specimen of Tensile Test

3.2 Welding Input Parameter

Welding speed is defined as the equation below:

$$Weld\ Speed = \frac{Elecrode\ travel}{Arc\ time}\ cm/min \quad (1)$$

Whereas the heat input denotes the energy transferred per unit length of weld as the ratio of the electrical power to the velocity of the heat source as given below:

$$Heat\ Input\ Energy = \frac{Volt \times Current \times 60}{weld\ speed}\ J/cm \quad (2)$$

Table 1: Welding input

No	Current (A)	Welding Speed(cm/min)	Heat Input(J/cm)
1	60	5,3	1418.86
2	95	5,3	18703.12
3	125	5,3	21875

The energy or the heat input is very important parameter in the making of shield arc welding. In this experiment, the arc welding process is performed by using either a.c or d.c of power source. The welding current consists of three types of amperage as shown in table 1. Therefore, the welding speed and heat input are adapted according to the welding current in order to obtain an optimum welding joint. In addition, the welding position is the significant factor that needs to be considered. American Welding Society (AWS) provides specific position in the welding process.

4.0 RESULT AND DISCUSSION

4.1 Tensile Test

(a) Without Welding (b) 60 A (c) 95 A (d) 125 A

Figure 3: Tensile test specimen

Figure 3 shows the experiment result of the tensile test that consists of 4 specimens. In the figure 3.(a), the specimen is not weld joint but it is the sample of same material and properties. The tensile test result displays the fracture of the specimen occurs exactly in the middle point which shows the ductile fracture. In ductile fracture, extensive plastic deformation (necking) takes place before fracture.

Figure 3.(b), (c), and (d) present the experiment result of the tensile test by applying the amperage of 60 A, 95 A, and 125 A. In this tensile test, the welded joints fail in the Heat Affected Zone (HAZ) region where the fracture of specimen occurs nearby the melted zone. It is indicating that the welding heat input has just influence on the mechanical properties of the Heat Affected Zone (HAZ) region, moreover the critical region exist in

Table 2: Result of Tensile Test

Specimen	L_0 (mm)	L_1 (mm)	Yield (kN)	Ultimate (kN)	Fracture (kN)
Non- Welding	50	67.1	33.1	47.39	37.8
60 A	50	58.3	34.6	47.61	47.6
95 A	50	62.1	32.68	46.69	37.8
125 A	50	63.2	35.28	47.60	39.2

Table 2 shows the characteristic value of the tensile test and the variation of tensile properties where the increasing of amperage is not always linear to the strength of material. Based on the tensile test result, the yield maximum strength is obtained for the amperage of 125A, but the maximum ultimate strength is occurred for the amperage of 60A. This condition indicates that the heat input contribute to the change of material properties. Concerning with the material fail of tensile test, the maximum value of fracture is occurred in the amperage of 60A.

4.2 Impact Test

In this study, the charpy V-notch impact test is performed to recognize the characteristic of the weld joint toughness with undersize test specimens whose thickness of 8 mm and length of 80 mm. The impact energy is determined by means of a swing pendulum where the pendulum is hoisted in a certain height to strike and break the specimen with the acceleration due to gravity of 9.8 m/s^2 and the weight falling contains a certain amount of the impact energy.

Table 3: Impact Test Result for the specimen

Amperage (A)	Initial Angle (α)	End Swing Angle (β)	Energy (J)
Non-welding	130	80	128.31
60	130	89	104.77
95	130	105	61.6
125	130	112	43.95

Table 3 shows the experimental results for charpy V-notch. Generally, it can be seen that the heat input of weld affects the mechanical properties of material where the increasing of welding amperage, the total absorb energy is decreased. This condition describes the increasing of heat input as well, which resulted in deeper penetration, wider melted zone and the change of metallurgical material at certain period of time during heating and cooling. The maximum absorb energy of 128.31 J resulted from non-welding workpiece that indicates the toughness of material. Whereas the welding workpiece that consists of welding amperage variation has the absorb energy trend lower than the non-welding work piece.

Referring to figure 4, this test provides a cross section of weld joint material. It shows the fracture model of impact test that indicate the properties of material after welding joint process. The lowest absorb energy describes the brittleness fracture in the melted zone. The increasing of welding amperage causes the joint material is more brittle.

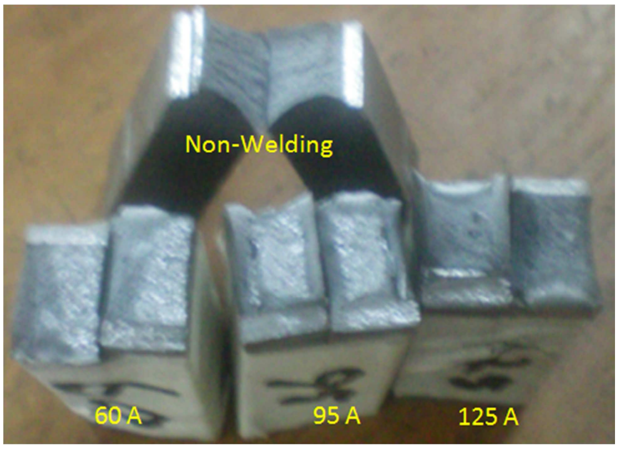

Figure 4: Charpy V-notch Test Specimen

5.0 CONCLUSION

In conclusion, this paper provides the result of tensile and impact test to ensure the toughness of weld joint that consists of welding amperage variation such as 60A 90A, and 125A. The tensile test results indicate that there is some anomaly of yield strength but it trend to be increased. The fracture point during the tensile test is always in the Heat Affected Zone (HAZ), it also indicate the critical region is in this region when it is subjected static loading.

The charpy V-notch impact test explains the behavior of welding joint material. The fracture occurred during impact test displays the trend of material brittleness significantly when it is subjected to dynamic loading.

REFERENCE

1. S. Parvez et.al (2013).*Effect of Torch Angle on Arc Properties and Weld Pool Shape in Stationary GTAW.* Journal Of Engineering Mechanics (ASCE)
2. C. Huanming and W. Shaojie (2012). *Effect of Arc Length on Weld Appearance and Metal Transfer in Twin-wire GMAW Process*. www.scientific.net/AMR.472-475.1279. Vols. 472-475, pp 1279-1282.
3. I.O Sadiq et al (2015). Effect of Process Parameters on the Shielded Metal Arc Welding of HY100 High Strength Low Alloy Steel. *International Journal of Advanced Research in Science, Engineering and Technology. Vol. 2, Issue 3,*
4. D.D. Zhang, W.Q. Qu1, Q. Meng ,P. Chai,G.H. Luan, J. Chen.*Effect of process parameters on the mechanical propertiesof friction stir welded Al-Li alloy butt joints.*Applied Mechanics and Materials Online: 2012-02-27ISSN: 1662-7482, Vols. 155-156, pp 1096-1101doi:10.4028/www.scientific.net/AMM.155-156.1096 (2012) Trans Tech Publications, Switzerland
5. Shujun Chen et al (2011). *Measurement and Analysis of the Welding Arc Current Density and Pressure Distribution based on Split Anode Method.* Proceedings of the 2011 IEEE International Conference on Mechatronics and Automation August 7 - 10, Beijing, China.
6. Sindo Kou (2003). *Welding Metallurgy*. Published by John Wiley & Sons, Inc., Hoboken, New Jersey.
7. American Welding Society (AWS). *Design For Welding.*Wed Mar 19 14:37:44 (2003).
8. Ibrahim Khan. *Welding Science and Technology.* NEW AGE INTERNATIONAL LIMITED,PUBLISHER. ISBN (13) : 978-81-224-2621-5 (2007).