Effect of Bevel Angle and Welding Current on T-Joint Using Gas Metal Arc Welding (GMAW)

Z. A. Zakaria, M. A. H. Mohd Jasri, Amirrudin Yaacob, K. N. M. Hasan and A. R. Othman

Abstract In this study, the effects of various welding parameters on welding strength in mild steel A36, welded by gas metal arc welding with fillet joint under 1F position were investigated. The welding current and the angle of bevel are the variable parameters, while welding speed was chosen as constant parameter. Each specimen's mechanical properties have been measured after the welding process, and the effects of the welding parameters on the strength were investigated. Then, the relationship between welding parameter and mechanical properties is determined. The project used 8 specimens to be studied and to find the best welding parameters for mild steel plate on fillet joint (1F position). Based on the mechanical tests performed, the best welding parameters for the mild steel plate thickness of 5 mm T-joint fillet welds are obtained; it was 120 A for weld current with no bevel angle.

Keywords Welding · Welding parameter · Tensile · Hardness · Microstructure

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1 Introduction

Gas metal arc welding (GMAW) is one of the Arc Welding processes that is widely used in the industries nowadays. GMAW is a process where the continuous fed of the wire electrode or filler wire through the welding gun and the shielding gas on the base metal and there will be no slag covering on created welding bead. GMAW process was introduced to the industry in the late of 1940’s by Hobart and Devers. Aluminium wire was the first electrode used and argon gas as the shielded gas. In the early 1950’s the first GMAW process was developed for the steel metal by using steel electrode by Lyubavshkii and Novoshilov, but due to high weld spatter, this process was not very user friendly. As time passes, this process has been through lot of innovate and now become one of the important welding process [1].

Butt, corner, tee, lap, and edge are the basic types of welding joint. The right angle joint of two members are called tee joint. In cross section, letter “T” shape appears for t joint and L-shape for the corner joints. This type of joint is under fillet type of welding. The joining of two surfaces materials with the right angle shape in triangle to each other is under fillet weld type. The effect of bevel angles and welding current on the mechanical properties of fillet joint under 1F position was studied in this research.

2 Literature Review

2.1 Welding Parameters

The proper choice of weld parameters can result in a high quality of weld. However, these variables cannot be changed by single parameters only, and to achieve the desired result, others parameters need also to be changed rather than changing one variable only. A good set up of these variables or in the other word the best recipe of the setting will result in high quality weld metal [2].

2.2 The Effect of Welding Current

The correct setting of current will not disappoint the end result. Too low current setting may cause insufficient heat to melt the metal base. Thus it will make the molten pool to be too small, pile up, and look irregular. However, if the current setting is too high, it will cause the weld molten pool to be large and irregular due to overheating and the fillet wire melting too fast [3].

2.3 The Effect of Bevel Angle

It is discovered that better mechanical properties can result from the preparation of the V-groove edge. Based on this case study, it is identified that more amount of weldment deposit on material with V-groove edge compared to straight edge [4]. It was suggested that smaller angle is better as long as the angle of groove can complete a penetration groove [5].

3 Experimental Works

The material for the plate is mild steel or low carbon steel is ASTM A36. This type of metal has high welding properties and it is eligible for punching, drilling grinding and machining process. It is a common steel grade being used for structure. A36 has high yield strength, thus making it have a high bending capability [6].

The specimens that are used to carry out this project are ASTM A36 low carbon steel with the dimension of 70 mm × 300 mm × 5 mm flat bar as in Fig. 1. In this project the joint type is t-joint and welded under 1F position with one sequence layer on both side. 45° angle of bevel was selected to the variable in this project. The welding machine that is used to perform this welding is PHOENIX 330 Expert Pulse force Arc. This task or project used GMAW welding process manually. The welding process parameters distribution is shown as in Table 1. Three mechanical tests were executed on the welded plate, tensile test, Brinell Hardness test and macro test.

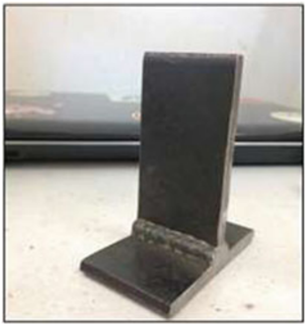

Fig. 1 Welding test sample

4 Testing

4.1 Tensile Test

Tension test is another word for the tensile test. It is a common type of mechanical tests performed on material. When the material being pulled, the strength will be measured by how much it will elongate. Then, the specimens were assembled with a clamp or jig. The bolt and nut need to be used to ensure the clamp and the specimen was strongly attached as in Fig. 2. Tensile test machine by Victor brand was used to complete this test. The total specimens for tensile test in this project were 27 pieces for each panel. All of these were done with the additional clamp or jig with the speed flow rate of 1 mm/min.

4.2 Brinell Hardness Test

Brinell hardness testing is usually done on material that has structure and rough surface. Typically for iron and steel material, the applied force is up to 3000 kg with

Table 1 Welding process parameters

Parameters	No.	Current (A)	No.	Angle (°)
Variables values	1	90	1	0
	2	100		
	3	110	2	45
	4	120		

Fig. 2 Specimen was set at the machine by using flat face wedges grip and firmly holds

10 mm diameter carbide ball as the intender. Specimens that are used for hardness test are 16 specimens. 187.5 kgf was applied on the intender ball with 2.5 mm diameter.

5 Result and Discussion

5.1 Ultimate Tensile Strength

In these experiments, it used 8 specimen with different welding parameters. From Fig. 3, the tensile results obtained show that maximum tensile strength of 377 MPa is possessed by the specimens made using 120 A weld current and non-bevel. The medium value of the tensile strength was 309 MPa, shown by the specimen with the current value 100 A and non-bevel. The lowest value of ultimate tensile strength was the specimen with the setting parameters of 90 A current and 45° angle of bevel that is 272 MPa.

As stated above, welding current of 120 A welding current and no bevel angle has a high tensile strength and ductility. Considering that, this is the right setting of welding parameters for GMAW process. Higher the voltage and ampere will give the effect on the heat affected zone of the weld area, especially during the solidification process between the filler and base metal.

In this project, bevel angle does not show lot of differences in UTS result and this may be due to thickness of plate that too thin which is 5 mm. The high value of UTS in this project was on no bevel angle specimen and the lowest value of UTS is on the specimen with bevel angle. Young modulus for tensile test was calculated and analysed after the test and the result can be seen in Fig. 4.

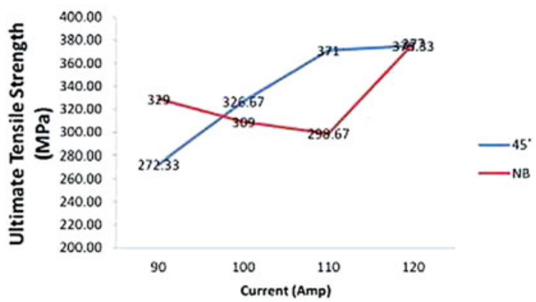

Fig. 3 Ultimate tensile strength (MPa) vs welding current

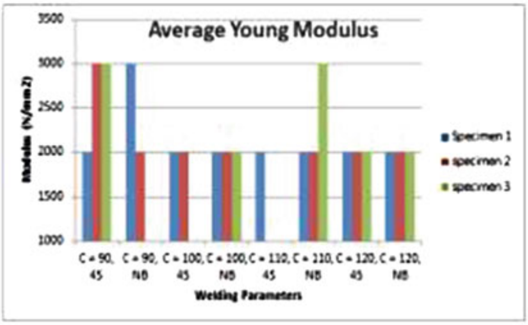

Fig. 4 Young Modulus versus welding current

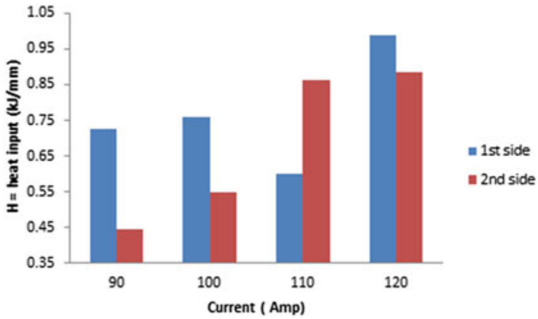

Fig. 5 Heat input versus current for 45° bevel angle

5.2 Average Young Modulus

The welding current of 90 A and with 45° bevel angle specimen shows the highest modulus elastic result. This shows that the specimen can stand with the maximum force imposed which means that it is not brittle or elastic. The lowest modules elastic result is shown by specimen of 110 A current value and 45° bevel angle. The average value of modules elastic was shown by specimen with welding parameters 120 A current. From this result, identified that specimen with 120 A current value is the best because its average is not brittle and elastic at the same time not too strong because it will cause wasted sources.

5.3 Heat Input

Based on this experiment, every specimen has 2 sides of weld. This section will shows the example of heat input calculation. Thus the data of the heat input in this project was tabulated in table and shown in Figs. 5 and 6. The formula of heat input as shown below.

$$H = I \times V \times 60/\,(S \times 1000)$$

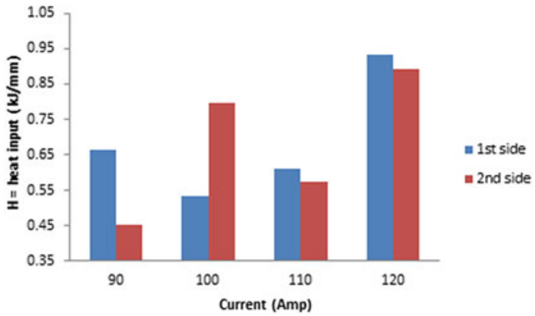

Fig. 6 Heat input versus current for no bevel angle

where H is heat input (kJ/mm), I is current (A), V is arc voltage (V) and S is travel speed (mm/s).

5.4 *Brinell Hardness*

Two point indents have been made for each specimen (HAZ and base metal). The radius of the indention is then measured through a special microscope and data is recorded. Data obtained must be multiplied by the scale of 0.05 set in a special microscope. Then the formula of Brinell hardness number was applied. Formula of Hardness Brinell is shown below:

$$BHN = \frac{2F}{\pi D\left[D - \sqrt{\left(D^2 - d^2\right)}\right]}$$

In above equation, F is the applied force (kgf), D is diameter of indenter (mm) and d is diameter of indentation (mm).

Figure 7 showed the hardness results for the specimens with different welding currents. From the result, the hardness of the HAZ did not grow until it reached the base material. The highest value of BHN for base metal was 187 that by specimens with welding current 90, 100 and 110 A with angle of bevel was 45° and no bevel. The highest value of BHN for HAZ area was 170 A shown by specimens with welding parameters 100 A at no bevel, 110 A at 45° bevel angle and 120 A both with no angle and 45° bevel angle. The result data showed that 120 A was the highest value of BHN on the HAZ area. High BHN values show that the indention diameter is small. This means that, the strength of the specimen or material surface is great.

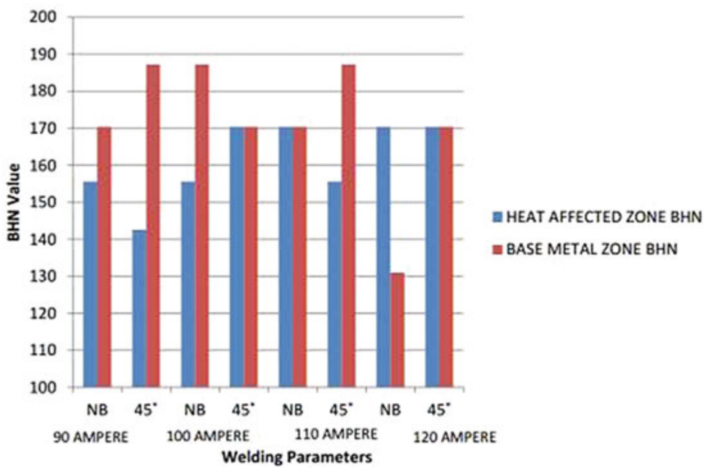

Fig. 7 Hardness Brinell number versus welding current

5.5 Discussion

From this experiment result of tensile test shows that, 377 MPa is possessed by the specimens made using 120 A weld current and non-bevel. The medium value of the tensile strength was 309 MPa that is the specimen with the current value 100 A and non-bevel. The lowest value of ultimate tensile strength was the specimen with the setting parameters of 90 A weld current and 45° angle of bevel that is 272 MPa. Hardness results for the weld shows that the highest value of BHN for base metal was 187 BHN shown by the specimens with welding current 90, 100 and 110 A with angle of bevel was 45° and no bevel. The highest value of BHN for HAZ area was 170 BHN by specimens with welding parameters 100 A no bevel, 110 A 45° bevel angle and 120 A both with no angle and 45° bevel angle.

The result of the heat input calculation as shown in Figs. 5 and 6 identified that, the highest value was specimen with welding parameters of 120 A current and no bevel angle that is 0.93 and 0.89 kJ/mm on both sides respectively. In relation to the tensile result, this specimen has a high value of UTS and during the tensile test, the specimen broke at the parent metal not at weldment area.

It can be concluded that the welding parameters for specimen 8 can be considered as the suitable and right set for the welding process. The current should be in high level because medium and lower level will settings affect the strength of the joint and may produce incomplete fusion due to not enough heat. No Bevel angle for t-joint of 5 mm thickness of mild steel is suggested based on the result found above.

6 Conclusions

As the conclusion, the objective of this experiment was achieved. The strength analysis on 1F welding position (fillet weld) on variable welding parameters by using tensile test and hardness has been done. The study determined that the process parameters to obtain maximum values for the weld properties were 120 A for welding current, and no bevel angle for low carbon steel plate of 5 mm thickness.

To choose between 90 and 120 A for the optimum parameter, it is essential to remember that the depth of penetration can give an extra point of successive welding. The current 120 A based on this experiment is optimum parameter than the others or below than that. Finally, the results of the mechanical test showed that, welding parameters influence the weld joint structure.

7 Recommendations

It is recommended that the research can be continued with other materials, plate thickness or welding process which can give better welding quality. Next researchers are encouraged to continue this experiment with different welding parameters, for example the voltage, heat input and etc. Pertaining to T-joint weld, the design of the clamp or jig for tensile test are recommended to have good preparation. The top part of the jig should stronger than the bottom part and the slot size of the welded specimen must be not too large to obtain accurate result of tensile test. The result obtained from the research experiment can be compared with the result obtained from this experiment. Based on the test result, this research can be further enhanced by increasing the number of testing specimens. So, the best of parameter and results obtained more accurate. Welding technology is a very large syllabus and a lot of things can be studied and investigated to produce high quality welding.

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