Effect of DE-GMAW (Double Electroda Gas Metal Arc Welding)’s Resistance on Mechanical and Physical Properties of Aluminium Alloy Weld

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Effect of DE-GMAW (Double Electroda Gas Metal Arc Welding)'s Resistance on Mechanical and Physical Properties of Aluminium Alloy Weld

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Abstract. This paper presented the effect of DE-GMAW (Double electrode gas metal arc welding) resistance on mechanical and physical properties of aluminium alloy welded. DE-GMAW is a method of welding process that use two electrode. A non consumable torch is added to bypass the current in order to reduce the heat input. The variation resistance used were 15Ω, 30Ω and 45Ω. Universal testing machine and Vickers microhardness were used to measured mechanical properties of weld metals with respect to strength and hardness. The microstructure was investigated by microscope optic with 100 x magnification. The grain size of weld metals with resistance value 30Ω is finer than 15Ω and 45Ω. Dye penetrant test shows DE-GMAW welding machine that made have good performance because it can produce welding joint without surface crack. The results show that resistance values optimum to DE-GMAW welding on aluminium alloy 5051 with 4 mm thickness is 30Ω. It can be seen from the tensile test that shows the highest tensile strength is found in the DE-GMAW welding with resistance values 30Ω.

Introduction

The great challenge in the automotive industry is to reduce vehicle weight by using a light aluminum alloy with excellent corrosion resistance for fabrication the car body [1, 2]. The reducing of weight will improve the fuel efficiency [3-5]. On the other side aluminum has low melting point so that in the joint by using the welding process required a low value of heat input.

A structure of Double Wire Gas Metal Arc Welding (DW-GMAW) which laid foundation for current Double Electrode-Gas Metal Arc Welding (DE-GMAW) were proposed by Ashton and Steinert (1954) [6]. Person and Ruzek (1956) improve DW-GMAW and proposed a tandem system [7]. Prof Zhang (2010) put forward a new method of DE-GMAW. DE-GMAW is a new welding process that used GTAW (Gas Tungsten Arc Welding) torch was added into GMAW system. With the bypass part of the current through the base metal the heat input was reduced [8]. The heat input could be well controlled by controlling the bypass current. This method used to aim the low heat input and the welding current should not exceed the maximum limit

Experimental

Welding System. The base metal in the dimension of 150 mm x 50 mm x 4 mm and the composition of materials provided in Table 1. The main welding parameters are listed in Table 2. The welding process used DE-GMAW (Fig. 1).

Table 1. Chemical composition of Al 5051 (% wt).

Element	Si	Fe	Cu	Mn	Zn	Ti	Cr	Pb	Ni	Sn	Al
Content	0.06	0.2351	0.043	> 1.8924	0.0353	0.0045	0.192	0.0029	0.0009	0.0052	Balanced

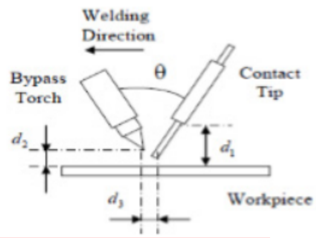
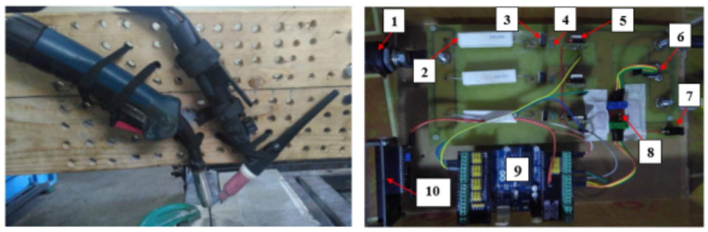


Fig. 1. Schematic of DE-GMAW Process [9].



(a) (b)

Fig. 2. Double Electrode Gas Metal Arc Welding
(a) Mechanism of DE-GMAW, (b) Control system DE-GMAW.

where, 1 = Plug Welding Connector, 2 = Resistor 15 W 1,2 Ω, 3 = Mosfet, 4 = Resistor 10 KΩ, 5 = Gate Driver , 6 = Current sensor, 7 = DC Power Jack, 8 = Low Pas Filter, 9 = Mikrokontroler, 10 = LCD + LCD i2c.

Table 2. Processing Parameters.

Processing Parameters	Details	
Diameter	Filler Wire	0.9 mm
	Bypass tungsten	1.2 mm
	Root-sided tungsten	1.2 mm
Speed	Welding	0.312 m/min
	Wire Feeding	5.1 m/min
Current and Voltage	Filler melting current	100 A
	Bypass current	35 A
	Voltage	14 V
Flow rate (Argon)	MIG torch	15 L/min
Distance and Angle	Contact tip to workpiece	10 mm
	Bypass tungsten to workpiece	4 – 6 mm
	Root-sided tungsten to workpiece	1.5 mm
	Bypass tungsten to wire tip	2 – 5 mm

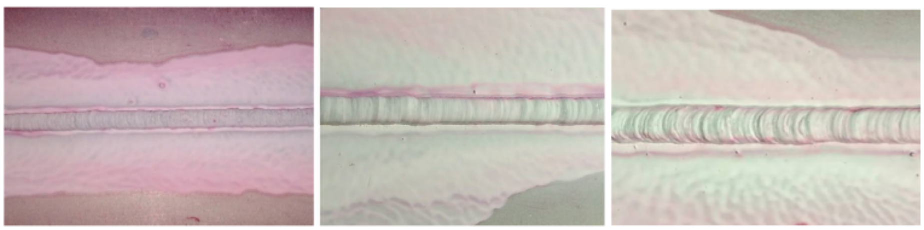
Physical and Mechanical Properties. The mechanical properties of butt joint were tested according to the standard of ASTM E-8. A universal testing machine was used to test the tensile strength of weld joint. Three tensile speciments were prepared in each variation of resistances to obtain an average mechanical values. The measurement of hardness was used Vickers microhardness. The microhardness carried a load of 100 gr.

The physical properties examined with dye penetrant inspection and microstructure. The dye penetrant inspection used to locate surface-breaking defects in weld joint. Dye penetrant is fast, economical and widely used non destructive test method to detect surface-breaking discontinuities. Penetrant test is based upon the principles of capillary action where liquid penetrates into a cavity.

Microscope optic was used to examine microstructure of weld metals. The metallography samples were sectioned, ground, polished and etched. The etched that used was HF.

Results and Discussions

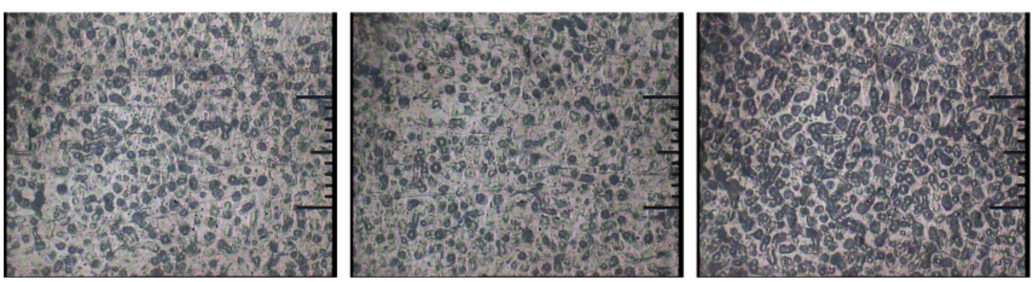
Dye Penetrant. The results of dye penetrant inspectien are presented in Fig. 3. Dye penetrant test results show that weld metal for all resistance has good quality because no cracks seen on the surface.



(a) Resistance 15 Ω (b) Resistance 30 Ω (c) Resistance 45 Ω

Fig. 3. Dye penetration specimen.

Microstructure. Fig. 4 shows microstructure of weld metals. That were no signification in microstructure of DE-GMAW weld metals with variation of resistance. The grain size of weld metals with resistance value 30Ω is finer than 15Ω and 45Ω. The substantial grain growth has occurred with proper values of heat input [10].



(a) Resistance 15 Ω (b) Resistance 30 Ω (c) Resistance 45 Ω

Fig. 4. Microstructure of Weld Metals.

Tensile Strength. Fig. 5 Shows the tensile strength of DE-GMAW welded with variataion of resistance. The diagram shows that tensile strength of weld metals with resistance 30 Ω has highest value. This value is 44.54 % higher than weld metals with resistance 45Ω and 18.52 % higher than weld metals 15Ω. The tensile strength of weld metals is correlated with the grain size of microstructure.

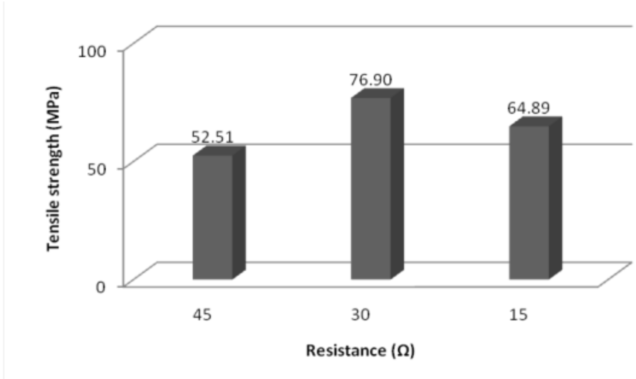


Fig. 5. Tensile strength of welding metals.

Hardness. The hardness of base metal, HAZ and weld metal of DE-GMAW welded with variation of resistance is given in Fig. 6. The weld metal is harder than raw material followed by HAZ (Heat Affected Zone). For all variation resistance , there were no significant trend difference the hardness number of base metal, HAZ and weld metal of aluminium alloy 5051 because it is non-heat-treatable material.

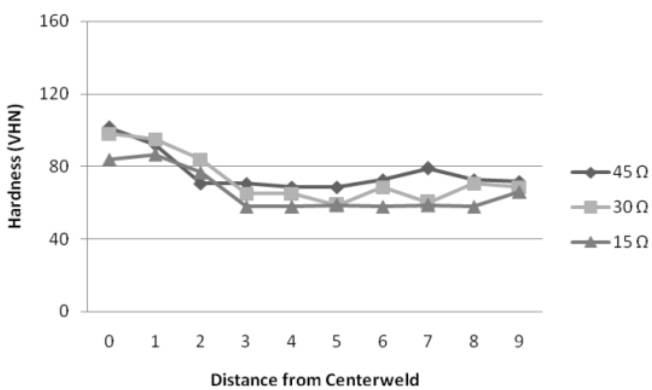


Fig. 6. Distribution of hardness.

Summary

The characteristics involving the variation in resistance values of DE-GMAW process for aluminum alloy were systematically investigated with conclusions drawn as follows:

- Welding machine that made in this research have good performance because it can produce welding joint without surface crack.
- The optimum resistance values to DE-GMAW welding on aluminium alloy 5051 with 4 mm thickness is 30Ω.
- The tensile strength of weld metals with resistance 30 Ω has highest value.
- There were no significant trend difference the hardness number of base metal, HAZ and weld metal of aluminium alloy 5051 because it is non-heat-treatable material.

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