INTERNATIONAL JOURNAL OF ENGINEERING TECHNOLOGY AND SCIENCES (IJETS) Vol.3 (1) June 2015
DOI: http://dx.doi.org/10.15282/ijets.3.2015.1.11.1028

The effect of filler ER4043 and ER5356 on weld metal structure of 6061 aluminium alloy by Metal Inert Gas (MIG)

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Abstract*— Weldability can be defines as the ability of a material to be welded under imposed conditions. Good weldability of aluminums alloys leads to have wide applications in marines, aircraft construction, aerospace and automobile industries. In this study, 6061 aluminum alloys will be joined by using automatic metal inert gas (MIG) welding machine. The filler metal used is ER5356 and ER4043. ER5356 filler contains 5.5% of magnesium and ER4043 filler contains 6% of silicon. The objectives of this research are to study the consequence of filler metal on mechanical properties of 6061 aluminum alloys. Based on the results, ER5356 showed highest tensile strength. The maximum tensile strength fabricated using ER5356 obtained at 204.27 MPa and ER4043 obtained at 200.66 MPa. The hardness value of ER5356 and ER4043 at welded zone using MIG is 63.4 HV and 40.9 HV.

***Index Terms*— Aluminium Alloy, Metal Inert Gas, AA6061, ER5356, ER4043**

I. INTRODUCTION

Metal inert gas (MIG) welding process is an vital element in various industrial processes nowadays due to its simplicity, versatility, rapidness and easiness of the training [1-4]. AA6061 is heat treatable aluminium alloy with main alloying elements of magnesium and silicon which displays great strength, excellent extrudability and good corrosion resistance [5]. Because of the following characteristic, it is make AA6061 the most widely used especially in automotive industry [4, 6]. However, nearly all the heat treatable aluminium alloys are unfortunately disposed to hot cracking. The susceptibility to solidification cracking is significantly influenced by the composition of the weld metal and therefore the appropriate selection of filler material is an imperative characteristic in monitoring solidification cracking [7, 8].
In present work, the effects of two different filler wire ER5356 and ER4043 with various parameters on the weldabilty of similar AA6061 welded by MIG process were carried out.

II. EXPERIMENTAL PROCEDURES

A. Materials and mix design

AA6061 with thickness of 2 mm were cut by using shear machine to dimension of 150 mm × 150 mm then being welded by single pass welding with square butt joint configuration. The chemical compositions of material and filler wire as shown in Table 1. The operations were performed by using automated table and MIG welding type Dr Well DM-500 as shown in Fig. 1. The parameter used in this operation were welding current, welding voltage and welding speed.

Fig. 1. Automated table and MIG welding type Dr Well DM-500

B. Experimental test

For tensile test, the welded AA6061 were cut by using Electron discharge machine (EDM) model Sodick AQ535L followed American Standard Testing Material (ASTM) E8M-04. The schematic diagram of tensile specimens was shown in Fig. 2.

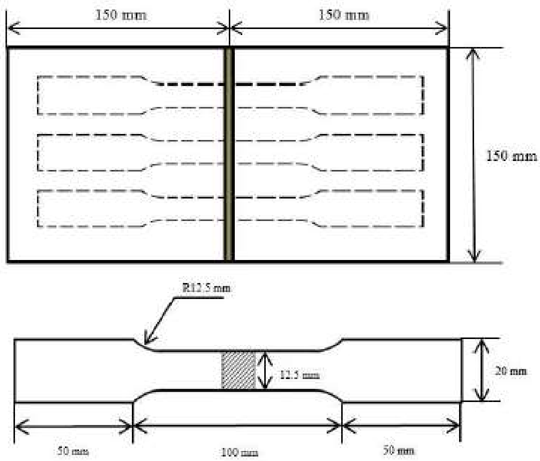


Fig. 2. Schematic diagrams for dimensions of specimen for tensile test

For hardness test, the specimens were cut into 10 mm. The specimens were then hot mounted, grinded and polished. The specimens were etched by Keller Reagent for microstructural observation. The hardness of weld was measured by Matsuzawa MMT-X7 Vickers hardness test.

III. RESULTS AND DISCUSSION

Total of 28 experimentations with combination of different parameter of welding current, arc voltage and welding speed both filler wire were performed.

A. Macrostructure

The MIG welded specimens were exposed to metallographic with magnification of 10X investigation prior to macrostructure survey. The resulted photographs were illustrated in Table 2 for welded using filler ER5356 and in Table 3 for welded using filler ER4043. From the result obtained, by using filler ER5356 and ER4043 the highest strength recorded is 204.27 MPa and 200.66 MPa, respectively.

B. Microstructure

Fig. 3 (a), in the HAZ region, the average grain size measured was 65.86 µm. Meanwhile, the FZ region shows the average measured grain size was 36.02 µm. Fig. 3 (b), represent a fine grain size at the fusion zone, therefore the tensile strength value obtained was 204.27 MPa.

Fig. 4 (a), in the HAZ region, the average grain size measured was 91.65 µm. Meanwhile, the FZ region shows the average measured grain size was 51.4 µm. Fig. 4 (b) represent a dendritic grain size at the fusion zone, therefore the tensile strength value obtained was 200.66 MPa.

C. Hardness Test

The effect of filler ER5356 and filler ER4043 on the distribution of hardness value in welded cross section were illustrated in Fig. 5 and Fig. 6, respectively. In the fusion zone (FZ) region, value recorded for welding using filler ER5356 were 62.5 HV, higher compared by using filler ER4043, with value of 46.87 HV. This is due to, ER4043 with high Si content not as strong as ER5356 with Mg is the main alloying element which is make the strength much more than using ER4043 [9] [10].

D. Tensile Test

Tensile test were conducted by using Universal Testing Machine Instron with 3369.50 kN load applied to the tensile specimens. The crosshead speed to pull the specimen at 1 min/mm was used. The tensile stresses of these three specimens were recorded and then the averages of the value were calculated in order to obtain the results. Fig. 7 represents the comparison tensile stress of different filler. From the graph, it is described that, higher tensile stress but lower stress elongation were obtained.

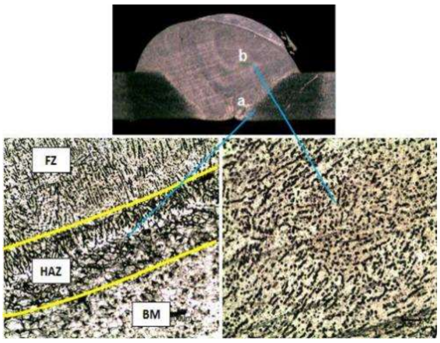


Fig. 3. Cross-sectional microstructure of MIG welding by using ER5356
a) 5x heat affected zone b) 20x fusion zone

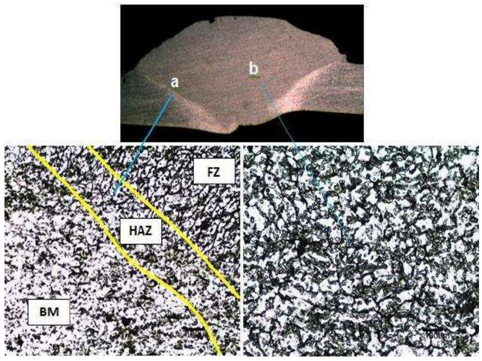
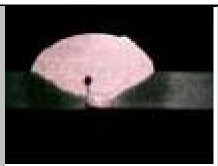


Fig. 4. Cross-sectional microstructure of MIG welding by using ER4043
a) 5x heat affected zone b) 20x fusion zone

Table. 1. Chemical composition of materials and filler wire

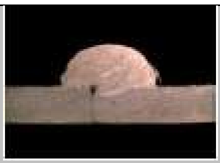
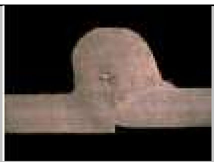
Material	Al	Si	Fe	Cu	Mn	Mg	Zn
AA6061	Bal	0.890	0.33	0.29	0.025	0.86	0.007
ER5356	Bal	0.25	04	-	-	5.5	0.10
ER4043	Bal	6.0	0.8	-	-	0.05	0.10

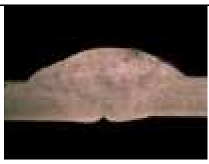
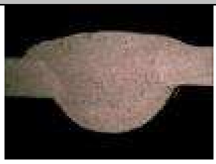
Table. 2. The variable parameters with ranges, heat inputs and quality of welding appearances by using filler ER5356

Specimens No	Macrostructure	Current (A)	Voltage (V)	Speed (mm/s)	Heat Input (J)	Tensile Test (MPa)
1		105	19	4	498.75	97.77
2		105	17	4	446.25	136.83
3		110	17	5	374.00	192.65
4		110	19	3	696.67	189.54
5		110	19	5	418.00	88.57
6		115	18	5	414.00	151.91
7		105	18	5	378.00	178.37
8		105	18	3	630.00	196.78
9		115	19	4	546.25	147.24

10		110	18	4	495.00	201.37
11		110	17	3	623.33	204.27
12		115	18	3	690.00	202.35
13		110	18	4	495.00	109.77
14		115	17	4	488.75	147.96

Table. 3. The variable parameters with ranges, heat inputs and quality of welding appearances by using filler ER4043

Specimens No	Macrostructure	Current (A)	Voltage (V)	Speed (mm/s)	Heat Input (J)	Tensile Test (MPa)
1		105	19	4	498.75	198.30
2		105	17	4	446.25	71.48
3		110	17	5	374.00	75.78
4		110	19	3	696.67	200.66
5		110	19	5	418.00	130.73
6		115	18	5	414.00	74.16
7		105	18	5	378.00	84.83
8		105	18	3	630.00	141.99
9		115	19	4	546.25	198.46

10		110	18	4	495.00	111.98
11		110	17	3	623.33	57.62
12		115	18	3	690.00	180.43
13		110	18	4	495.00	123.88
14		115	17	4	488.75	75.47

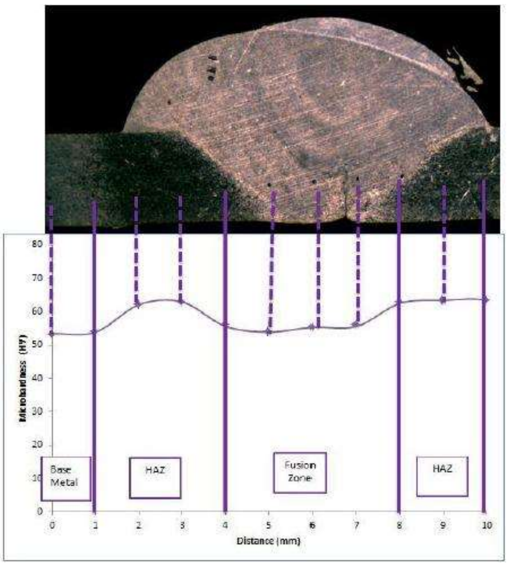


Fig. 5. Hardness value using ER5356.

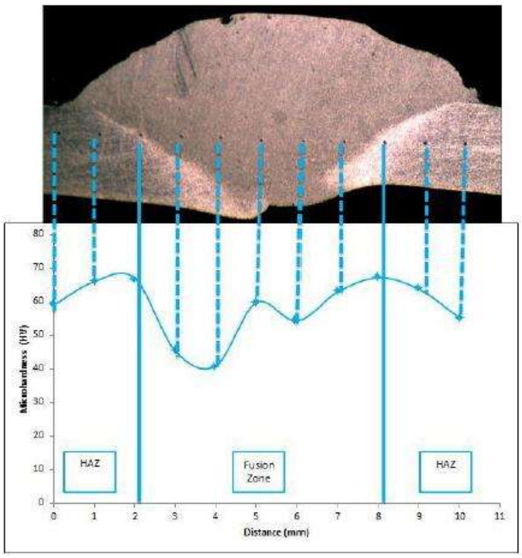


Fig. 6. Hardnes value using ER4043.

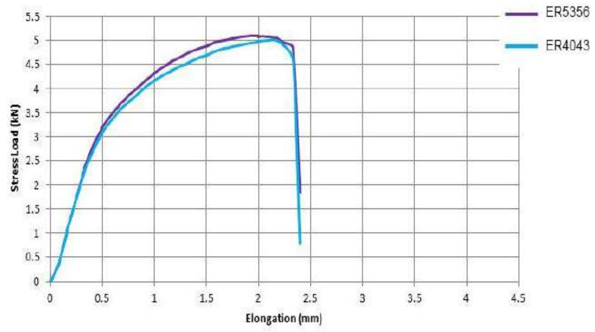


Fig. 7. Tensile strength of welded specimens by using different filler wire

IV. CONCLUSIONS

The following conclusions can be drawn from this research:

i. The weld joint fabricated by ER5356 show highest strength which is 204.27 MPa compared to ER4043 at 200.66 MPa by using MIG welding.

ii. MIG specimen joined using ER5356 obtained highest microhardness which is 63.4 HV at welded area and followed by ER4043 at 40.9 HV.

iii. Welding with ER4043 produced defects such as distortion and cracks. However, fewer defects occurred to weld using filler ER5356.

iv. In this research, its shows that, weldability of AA6061 is better by using filler ER5356.

V. ACKNOWLEDGMENTS

The author would like to thank the technical staff of Universiti Malaysia Pahang for all of the work within which the experiments were conducted. Also, financial support by the Ministry of Education Malaysia through Universiti Malaysia Pahang for Fundamental Research Grant Scheme (FRGS), project no. FRGS/1/2013/TKOI/UMP/02/2 is gratefully acknowledged.

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