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Comparative Analysis on Effect of Various Filler and Groove Angle on TIG Welded AA6082

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Abstract: Nowadays most of the automobiles aerospace and fabrication industries were started using of aluminium alloys for making the product. This is due to the properties given by the aluminium alloys are more efficient than the other metals. That might be include high tensile strength, sufficient hardness value and very less formation of defects in the welded zone and it is very low cost while comparing the other metals. For investing the mechanical properties of AA6082, the two different fillers and grove angles were taken. That they are ER5556 and ER4043 and groove angles are 45° and 60°. The aluminium plates were welded by TIG welding method which provides more joint efficiency of aluminium metals. After the welding the weld plates were taken into various mechanical and microstructure evaluation. The specimen welded with ER5556 and groove angle of 45° provides more tensile strength and sufficient hardness in the weld joint. In the microstructure examination, the weld joints have uniform distribution of aluminium silicon. The specimen welded with ER5556 and groove angle of 45° an 60° have very less defects which is easily eliminated during welding.

Keywords: TIG Welding, Filler Metal, Aluminium Alloy, Tensile strength.

1. INTRODUCTION

There are numerous processes are involved to make a product in the fabrication industry. In those welding is a process which occupies a dominant part in the overall product. This welding process furnishes a look on fabricated product. In the welding method, two or more metals or unlike metals can be merged together by applying the heat or pressure and with or without the addition of filler on the edges of metals. By cooling the joint it became permanent. This welding method can be categorized by two major group arc welding and solid state welding which can be additionally grouped based on its characteristics. In arc welding method, heat and fillers are used to join the metal surfaces. A sole welding method which uses the tungsten filler metal called tungsten inert gas welding method.[1]The intention of using tungsten filler metal is to protect the weld pool from the atmospheric moistures. This TIG welding is extensively used for the welding of aluminium alloys. Aluminium alloys are broadly used in automotive and aerospace applications which are advance to the atmospheric inclusions hence TIG welding is preferred. A good weld joint must take over high strength to withstand the varying loads. In order to facilitate such strength the weld joint must have proper joint geometry. Making groove in the edges of metal plate before welding the joint will come up with better joint efficiency. [4]

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2. MATERIALS AND METHOD

2.1 Welding Method

Tungsten Inert Gas (TIG) welding also label as Gas Tungsten Arc Welding (GTAW), Heliarc and heliweld method. A non-consumable tungsten wire is used to produce a weld between the metal surfaces. Inert gas including helium or argon or other gas mixtures can be used to make joint in weld plates. This gas will impart a shielding for the weld zone. Basically it was developed for welding of aluminium alloys and other reactive metals, recently it can be applicable for almost all the metals.

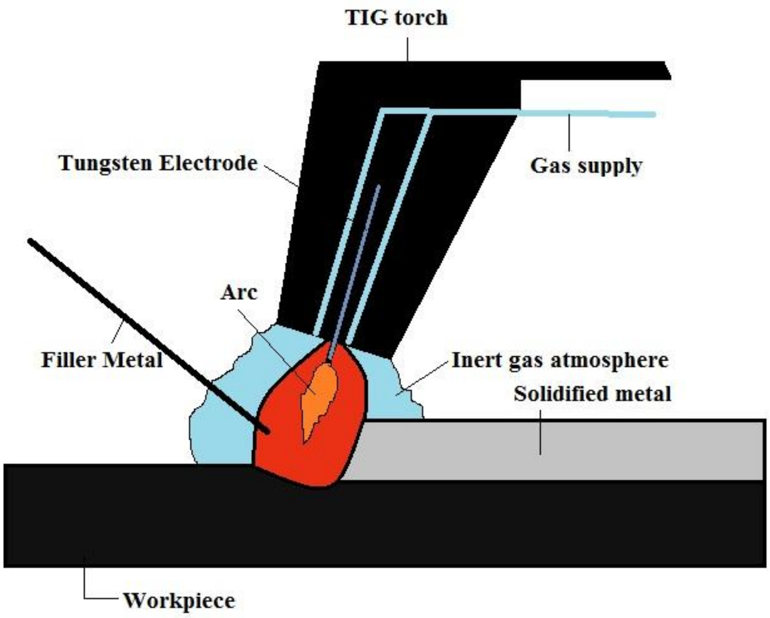

Fig 1. TIG Welding

The welding power source will be either A.C or D.C supply.[7] While using DCSP there will vast electron flow between the tungsten tip and metal plate. When working with thinner materials a backing plate has to be provided. This will protect the joint from porosity, poor surface appearance and weld puddle. The backup plate can be in the form of bars, inert gas atmosphere or flux backing. The most part application TIG is pipe welding for high pressure steam lines and chemical plants.

2.2Aluminium Alloy 6082

Aluminium alloy 6082 falls under the aluminium series and designation is 6xxx. Alloys which are in this series will have medium strength and good corrosion resistance. This is because of the composition of certain alloys. The AA6082 is having the maximum content of silicon and magnesium. This kind of Aluminium series can be termed as Al-Si-Mg alloys. AA6082 chiefly used for welded structures. Due to the non magnetic property, Aluminium alloys will not have the problem of arc blow.[10] MIG, resistance spot, TIG and seam welding are most acceptable method for welding of aluminium alloys. In that TIG welding can be put forward to welding of most aluminium alloys with the maximum thickness of 25mm. To get a better joint efficiency the base plates should follow proper welding procedure such as

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cleaning the surface followed by weld backing the preheating after that tack welding. TIG welding of aluminium alloys posses both AC and DC power supply.

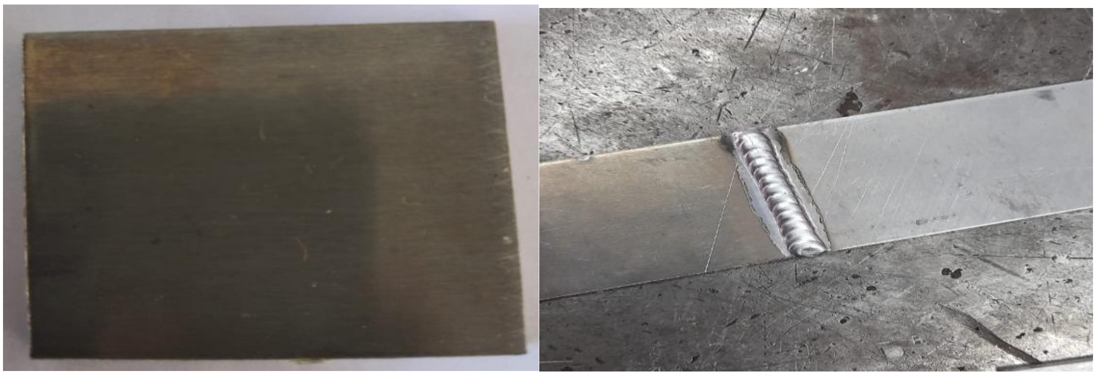


Fig 2. Aluminium Alloy 6082

Element	Si	Fe	Cu	Mn	Mg	Zn	Ti	Cr	Al
%	0.7-1.3	0-0.5	0-0.1	0.4-1	0.6-1.2	0-0.2	0-0.1	0.025	Remain

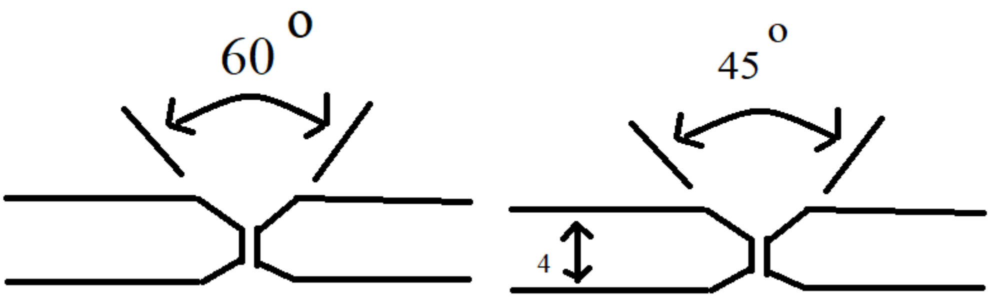
Table 1. Composition of AA6082

Base material	Ultimate Tensile Strength (MPa)	Yield Strength (MPa)	Elongation at Break (%)	Density
AA6082-T6	290	250	10	2.70

Table 2. Mechanical properties of AA6082

2.3Joint Geometry

Fabricating a welded structure will require different joints. This joint principle will have configuration as type of weld joint, type of groove, groove angle, root gap and others. Selecting a proper joint configuration is major factor in joint efficiency. Pipes in steam lines and chemical processing industries are principally joined by butt joints. These butt joint offers good penetration in the welded area as well as lack of cracks formation. This can be achieved b making grooves on the edges of metal surfaces and also the joint should have smaller root openings. Groove angles of Aluminium alloys in TIG welding process can have the angles as 45°, 50° and 60°.



(a) (b)

Fig 3. Joint design (a) 60 degree (b) 45 degree

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(a) (b)

Fig 4. Double V groove on AA 6082 (a) 60° (b) 45°

2.4 Filler Material ER 5556 and ER 4043

Bare electrodes can be used for aluminium alloys in TIG welding process. A proper filler metal should have base metal composition and suitable to joint design. Filler metal should be diluted at given current and not tendency to cracks. Commonly used filler metals for aluminium alloy 6xxx series are ER5556, ER5356, ER 5654, ER4043, ER5556 aluminium filler with have higher content of magnesium and zinc than 5356 which will yield increased crack resistance, tensile strength and good ductility.

Fig 5(a).ER 5556Fig 5(b). ER4043

Element	Si	Fe	Cu	Mn	Mg	Zn	Ti	Cr	Al	Be
% Present	0.25 max	0.40 max	0.10 max	0.5-1	4.7-5.5	0.25 max	0.05-0.2	0.05-0.20	Rem ain	0.0003 max

Table 3. ER5556 Composition

ER4043 have is a 5% Silicon Aluminum filler metal that is used primarily for welding Aluminum Alloys 6xxx series. ER4043 has a melting range of 1,065°F - 1,170°F. The post-anodizing color tint is gray.

Element	Si	Fe	Cu	Mn	Mg	Zn	Ti	Be	Al	Be
% Present	4.5-6.0	0.80 max	0.30 max	0.05 max	0.05 max	0.10 max	0.20 max	0.0003 max	Remain	0.0003 max

Table 4. ER4043 Composition

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2.5 Welding Parameters

Weld base material: AA6082

Filler Material 1: ER5556

Filler Material 2:ER4043(2.0mm)

Joint design: Double V groove Butt joint

Bevel angle: 45° and 60°

Root gap: 1mm

Welding current: 140A

Welding voltage: 13V

3. RESULTS & DISCUSSION

3.1 Tensile Test

3.1.1 Tensile Test: Groove angle 45° with filler ER5556

The specimen was prepared as per the dimensions and joints and the welding was carried out on the base metal. After welding the joints were ready for the examination of tensile strength. The welded metals were loaded in the UTM to observe the tensile strength.It is observed that tensile strength of the loadedspecimen is about 231 MPa

3.1.2 Tensile Test: Groove angle 45° with filler ER4043

After examining the tensile strength of the weld joint which welded with groove angle of 45° using the file ER4043 we found that the tensile strength of the loaded weld joint isabout 196MPa

3.1.3 Tensile Test: Groove angle 60° with filler ER5556

The specimen was prepared as per the dimensions and joints and the welding was carried out on the base metal. After welding the joints were ready for the examination of tensile strength. The welded metals were loaded in the UTM to observe the tensile strength. It is observed that tensile strength of the loaded specimen is about 214 MPa

3.1.4 Tensile Test: Groove angle 60° with filler ER4043

After examining the tensile strength of the weld joint which welded with groove angle of 45° using the file ER4043 we found that the tensile strength of the loaded weld joint is about 189MPa

Weld joint	**Tensile Strength (MPa)**
Groove angle 45° with filler ER5556	231
Groove angle 45° with filler ER4043	196
Groove angle 60° with filler ER5556	214
Groove angle 60° with filler ER4043	189

Table 5. Tensile Strength of weld joints

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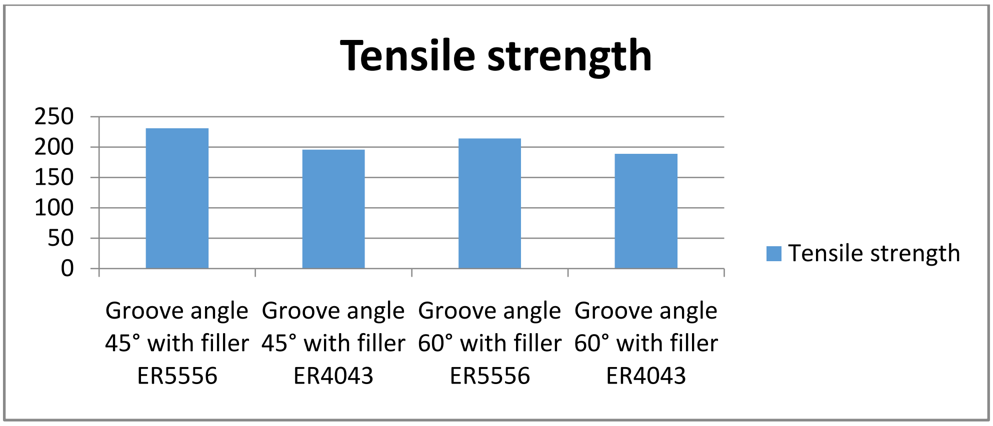

Fig 6. Tensile Strength

Among the all loaded specimen, the joint which welded with groove angle 45degree by the filler ER5556 provides maximum tensile strength of 231MPa than the other welded joints.

3.2 Hardness Test

The principal purpose of the hardness test is to determine the suitability of a material for a given application, or the particular treatment to which the material has been subjected.

	Base Metal 1	HAZ 1	Weld Metal	HAZ 2	Base Metal 2
Groove angle 45° with filler ER5556	70	61	53	64	73
Groove angle 45° with filler ER4043	74	66	57	62	71
Groove angle 60° with filler ER5556	71	65	59	66	73
Groove angle 60° with filler ER4043	73	69	61	67	70

Table 6. Hardness Value

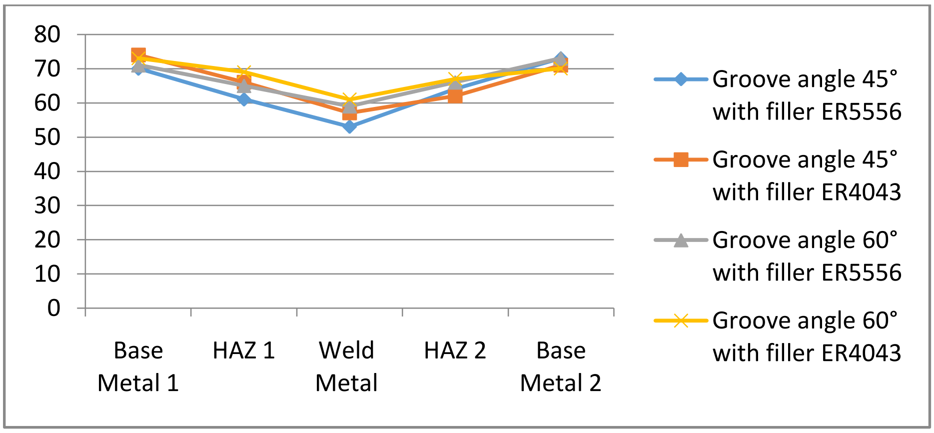

Fig 7. Hardness Range

From the graph it is observed that the joint welded with groove angle 45° with filler ER5556 provides more sufficient hardness for the joints.

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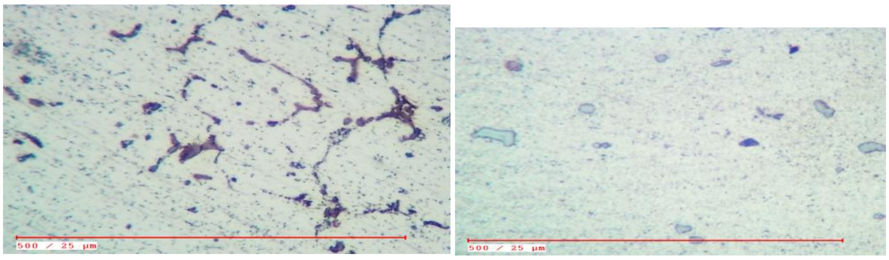
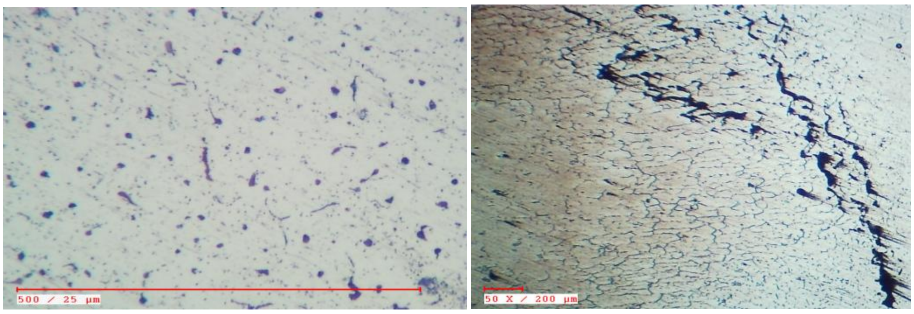
3.3 Microstructure Examination

From the examination, the following microstructure of specimen welded with groove angle 45° by the filler ER5556 is the evident for the present of inter-dendritic network of the aluminium silicon eutectic in matrix of aluminium solid solution. The welded joint is defect free grain structure with uniformly distributed aluminium silicon particles throughout the weld region. It implies that it can produce high tensile strength in wed joint.



(a) Groove angle 45° with filler ER5556(b) Groove angle 45° with filler ER4043



(c) Groove angle 60° with filler ER5556(d) Groove angle 60° with filler ER4043

Fig 8. Microstructure of welded samples

3.4 Liquid Penetrant Test

The objective of liquid penetrant testing is to provide visual evidence of surface discontinuities in solid non-porous materials. The specimen welded with groove angle 45° by the filler ER4043 shows some visible cracks as toe crack. This could be occurred due to improper cooling of weld joints. By following the procedure, LPT was carried out. It was found that the specimen welded with groove angle 60° by the filler ER4043 having the defects such as poor weld bead and traverse crack. This might be due to the low current during welding.

(a) Cracks on groove angle 45° by ER4043(b) Cracks on groove angle 60° ER4043

Fig 9. LPT of welded samples.

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Only the spatter defect was found in the specimen welded with groove angle 45° and 60° by the filler ER5556 joint. From the comparison above result it can be concluded that groove angle 45 and 60 by the filler ER5556 joint has very less defect and that also can be easily eliminated and that will not take part in the lack of joint efficiency.

4. CONCLUSION

The following conclusions were made after the conduction various examinations. That they are,

- Among the all loaded specimen, the joint which welded with groove angle 45 degree by the filler ER5556 provides maximum tensile strength of 231MPa than the other welded joints.
- The joint welded with groove angle 45° with filler ER5556 provides more sufficient hardness for the joints.
- The microstructure of specimen welded with groove angle 45° by the filler ER5556 is the evident for the present of inter-dendritic network of the aluminium silicon eutectic in matrix of aluminium solid solution. The welded joint is defect free grain structure with uniformly distributed aluminium silicon particles throughout the weld region. It implies that it can produce high tensile strength in wed joint.
- The weld joint made with groove angle 45° and 60° by the filler ER5556 joint has very less defect only the spatter defect was found in the joint and that also can be easily eliminated and that will not take part in the lack of joint efficiency.

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