Corrosion Study on FSW and GTAW Welded Joints of AA7175-T6

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ABSTRACT

Aluminium alloy 7175 treated with T6 condition of thickness 4mm were butt welded by Friction Stir Welding (FSW) and Gas Tungsten arc welding (GTAW) method. Process parameter decides the quality of weld in FSW and GTAW. Friction Stir Welding is done by varying the speed of rotation of tool and speed of the welding with constant axial load of 10KN. GTAW is done by varying current with ER4346 filler material. The welded joints are tested for its corrosion rate in Potentiostat with 3.5% NaCl solution. The corrosion behavior of welded joints was probed by Tafel polarization curve. This technique uses data obtained from cathodic and anodic polarization measurement. Tafel plats provide the direct measure of the corrosion current, which can related to corrosion rates. The result shows that FSW at 1200rpm has the higher corrosion resistance comparatively.

KEY WORDS: FSW, GTAW, Potentiostat, Tafel polarization curve.

1. INTRODUCTION

The coupled property of light weight and high machinability made aluminium, a promising material. Good electrical conductivity and high corrosive resistance are also its major advantageous properties. Aluminium has wide variety of applications in the fields such as processing industries, automobile sector, and also in aviation field. The aeronautic industries nowadays is increasing the application of Al-Mg-Si alloys due to its higher toughness, SAA 7175-T6 alloy.

Mating of aluminium alloys is possible by a new technique called Friction Stir Welding. In this case, a non-consumable tool which is rotated to produce frictional heat. This heat generated due to friction causes deformation at the welding area, to form the joint, while the material is in the solid state in friction-stir welding, a non-consumable rotating tool consisting of a pin and shoulder is plunged into the abutting edges of the plates to be joined and traversed along the line of the joint. Heat is produced by rotating the tool and moves the material to produce the joint. The heating is accomplished by the friction between the tool and the work pieces and it causes the plastic deformation of the work pieces to form the weld. The combination of the tool rotation and translation produces a joint by mixing the abutting edges of the work pieces, by means of the localized heat produced around the pin. The peak temperature generated during FSW is below the melting temperature of the material to be welded. Some of the benefits are (i) weld defects are lesser, (ii) good dimensional stability of the welded structure and possibility to weld linear and contour welding.

TIG welding (Tungsten inert gas welding) uses an electrode which is not consumed and it also uses a separate filler metal. The shielding gas used is an inert gas. The following power sources has to be utilized for GTAW welding, (i) An Argon gas cylinder, (ii) welding torch with power supply and cable connections to supply power, (iii) tubes for supplying the shielding gas and (iv)tubes provided with water inside for cooling of the torch. The torch has a different shape, and it protects the tungsten electrode due to accidents. TIG welding is mostly used for welding 2 series and7 series aluminium alloys. The main problem in TIG welding is the gap between solids and liquids in the weldment due to which heat affected zone gets liquation cracked. Carefully controlling the metallurgy of weld will help to result in the improvement of weldability.

The destructive effect of metal by chemical reaction with its environment is involved in corrosion. In other words, it is defined as gradual material destruction by chemical reaction with their surroundings. The main process involved in rusting is the oxidation phenomena. In rusting process, the original metal gets converted to metal oxides. Ceramics or polymers also suffer the problem of corrosion. The required properties of metals such as strength, appearance and mechanical behavior gets varied or degraded due to corrosion.

2. EXPERIMENTAL SETUP

The material used in this case is a high strength 4mm thick plate AA7175-T6 alloy to make FSW and GTAW butt welded joints. The composition of aluminium alloy 7175 is present in table.1. Power hacksaw cutting and grinding machines were used to cut the material into the required size (160mm*75mm). The butt joints are to be made in square shape as shown in fig.1, was prepared to do Friction stir welding. The two aluminium plates are clamped together mechanically to make the joints. Single pass welding procedure was used to fabricate the joints.

Table.1. Chemical composition of aluminium alloy 7175

Material	Al	Zn	Fe	Cu	Cr	Ti	Si	Mn	Mg
Weight%	89.5	5.6	0.2	1.6	0.23	0.1	0.15	0.1	2.5

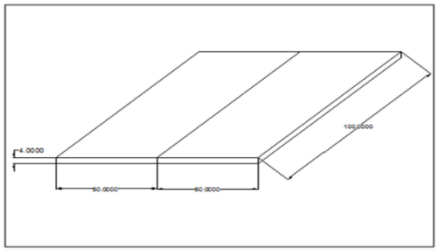

Figure.1. work piece setup

In FSW, for desiring the quality of weld, the major parameters considered were welding speed, tool rotation speed, and the axial force. In table.2, the parameters considered for the welding process are listed out. Depending on tool rotating speed we use corresponding welding speed and axial force. The non-consumable tool, which is a threaded cylindrical type made of high carbon high chromium steel was used to fabricate the joints. Tool profile is shown in fig.2, if the pin length is slightly shorter than the weld depth.

Table.2. FSW Welding parameters

Tool Rotating speed(rpm)	800	1000	1200
Welding Speed (mm/min)	50	60	70
Plunge Depth(mm)	3.6	3.6	3.6
Axial Force(KN)	10	10	10

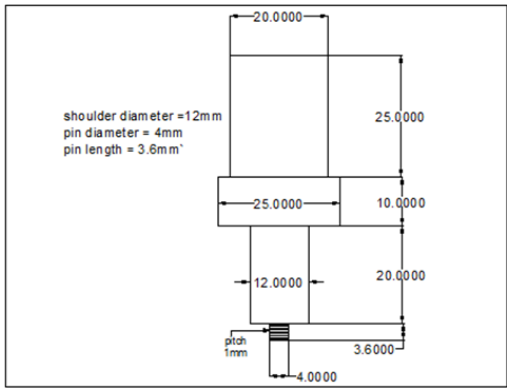

Figure.2. Tool profile for FSW

The same size plates used in GTAW welding process, Welding of the samples was carried out on Pulse GTAW 300 V AC/DC. A thorough wire brushing process had been done to eliminate moisture, oxide layer and oil from base metal. Process parameters and filler material selection are the two factors which decides the quality of weld. The process parameters values are selected depend upon the material thickness. In GTAW Welding current, Welding speed, Filler material diameter, types of gas and filler material are desiring the weld strength. Filler material ER 4346 and shielding gas argon are suitable for AA7175-T6 material. Table.3, shows different GTAW parameters used to fabricate various joints.

Filler material:

Table.3. GTAW Process parameters

	Current (Amps)	**Welding Speed (mm/min)**	**Filler ROD DIA. (mm)**	**Type Of Gas**
ER4346	80	120	2	Argon
ER4346	120	140	2	Argon
ER4346	160	160	2	Argon

FSW and GTAW welded specimens were cut in required size (20*20mm) for corrosion testing. Electrochemical impedance spectroscopy (EIS) testing was used to find out the corrosion rate with the help of polarization curves. The specimen's surface was grinded with the help of abrasive paper through 80 grade to 2600 grade, further degreased by using deionized water and then finally dried in air. The electrochemical tests have been conducted in 3.5%NaCl aqueous solution. The EIS experiment was done with the help of traditional compartment arrangement, where the working electrode was AA7175-T6 welded plates at welded zone. In the experiment, a large platinum sheet was made as the counter electrode and a saturated calomel electrode (SCE) with a lugging capillary was made as a reference electrode. A frequency range of 80Hz to 80MHz was selected to sense corrosion resistance. Between the working electrode and counter electrode, an alternating voltage was applied directly, where the voltage ratio of 10mV was maintained. In Germy Echem analyst using tafel polarization plot to find out Icorr, Ecorr and corrosion rate.

3. RESULT AND DISCUSSION

Tafel polarization plot of the FSW, GTAW weld were compared with base metal values. On analyzing these values, it was clear that the corrosion rate of base metal was 95.54mpy from Icorr and Ecorr value using tafel polarization curve. In FSW different welded specimen in various process parameters , with 800 rpm rotating speed and 50mm/min linear speed has a corrosion rate is 81.88mpy, 1000 rpm rotating speed and 60mm/min linear speed has a corrosion rate is 148.2mpy and 1200 rpm rotating speed and 70mm/min linear speed has a corrosion rate is 177.8mpy. In GTAW the welded specimen having the corrosion rate is 193.8, 169.02, 155.9mpy with various process parameters are welding current rate is 80, 120, 160 Amp with respectively welding speed are 120, 140,160 mm/min.

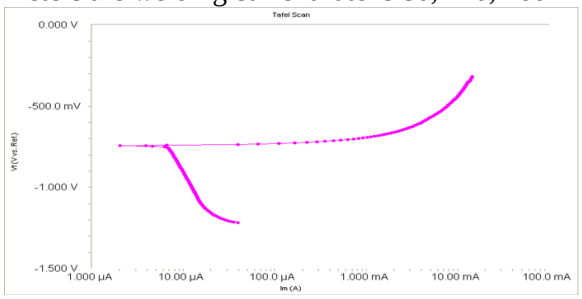

Figure.4. AA7175-T6 tafel polarization curve

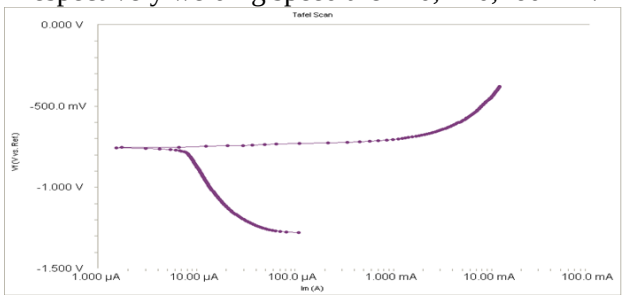

Figure.5. FSW 800rpm welding speed tafel polarization curve

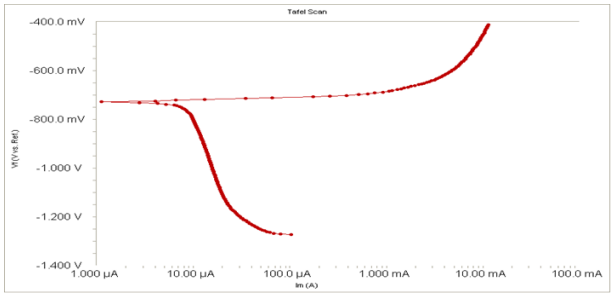

Figure.6. FSW 1000rpm welding speed tafel polarization curve

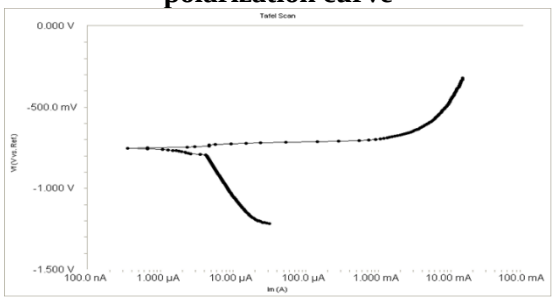

Figure.7. FSW 1200rpm welding speed tafel polarization curve

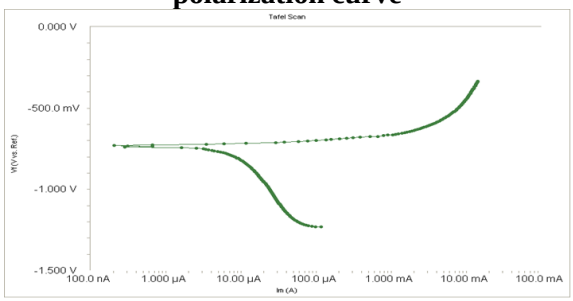

Figure.8. GTAW 80Amps welding current tafel polarization curve

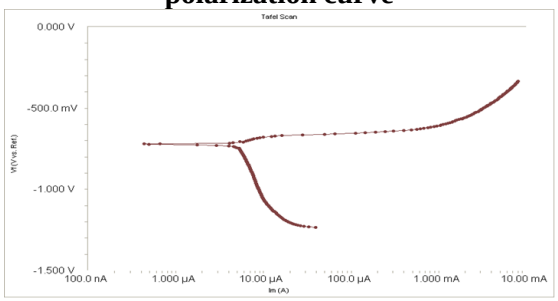

Figure.9. GTAW 120 Amps welding current tafel polarization curve

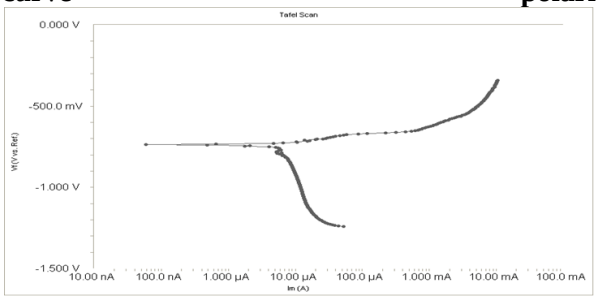

Figure.10. GTAW 160 Amps welding current tafel polarization curve

4. CONCLUSION

Based on the review of the results of welded AA7175-T6 aluminium specimens the following conclusions have been drawn:

- From the three welded FS Welded joints corrosion resistance of welded specimen at 1200rpm is very high.
- GTAW Welded joints at 160amps show higher corrosive resistance than welded joints at 80 and 120amps.

With all the welded specimens, Friction Stir Welded and GTAW Welded joints, FS welded specimens at 1200rpm shows higher corrosion resistance.

REFERENCES

Andreatta F, Lohrengel M.M, Terryn H, de Wit J.H.W, Electrochemical characterisation of aluminium AA7075-T6 and solution heat treated AA7075 using a micro-capillary cell, Electrochimica Acta, 48 (20), 2003, 3239-3247.

Andreatta F, Terryn H, de Wit J.W.H, Corrosion behaviour of different tempers of AA7075 aluminium alloy, Electrochimica Acta, 49 (17-18), 2004, 2851-2862.

Athijayamani A, Manickam C, Kumar J, Natesan Diwahar, Mechanical and wear behaviors of untreated and alkali treated roselle fiber-reinforced vinyl ester composite, Journal of Engineering Research, 3 (3), 2015.

Atkinson H.V, Bruke K, Vaneetveld G, Recrystallization in the semi-solid state in 7075 aluminium alloy, Materials Science and Engineering, 490 (1-2), 2008, 266-276.

Balasubramanian V, Relationship between base metal properties and friction stir welding process parameters, Materials Science and Engineering, A 480 (1), 2008, 397-503.

Cavaliere P, Squillace A, Panella F, Effect of welding parameters on mechanical and micro structural properties of AA7082 joints produced by friction stir welding, Journal of Materials Processing Technology, 200, 2008, 364-372.

Chandrasekar M, Rajkumar S, Valavan D, A review on the thermal regulation techniques for non-integrated flat PV modules mounted on building top, Energy and Buildings, 86, 2015, 692–697.

Da Silva A.A.M, Arruti E, Janerio G, Aldanonodo E, Alvarez P and Echeverria A,Material flow and mechanical behaviour of dissimilar AA2024-T3 and AA7175-T6 aluminium alloys friction stir welds, Materials and Design, 32 (4), 2011, 2021-2027.

Elsadig Eltai, Mahdi E, Akram Alfantazi, The effect of gas tungsten arc welding on the corrosion and mechanical properties of AA7061 T6, International Journal of Electrochemical Science, 8, 2013, 7004-7015.

Karthe M, Tamilarasan M, Prasanna S.C, Manikandan A, Experimental Investigation on Reduction of NOx Emission Using Zeolite Coated Converter in CI Engine, Applied Mechanics and Materials, 854, 2017, 72-77.

Kim I.S, Son J.S, Kim H.J, Chin B.A, Development of a mathematical model to study on variation of shielding gas in GTA welding, Journal of Achievements in Materials and Manufacturing Engineering, 19 (2), 2006, 73-80.

Krishnan M, T Karthikeyan.T, Chinnusamy TR, Venkatesh Raja K, A novel hybrid metaheuristic scatter search-simulated annealing algorithm for solving flexible manufacturing system layout Eur J Sci Res, 2012, 52-61.

Manickam C, Kumar J, Athijayamani A, Karthik K, Modeling and multiresponse optimization of the mechanical properties of Roselle fiber-reinforced vinyl ester composite, Polymer-Plastics Technology and Engineering, 54 (16), 2015, 1694-1703.

Prabhu T, Ramesh C, Kumar J, Sivakuma S, Hybrid Solar PVT System based on Neural Network Models to track optimal Thermal and electrical power, International Journal of Applied Engineering Research, 10 (28), 2015, 22075- 22081

Prasanna S.C, Ramesh C, Manivel R, Manikandan A, Preparation of Al6061-SiC with Neem Leaf Ash in AMMC's by Using Stir Casting Method and Evaluation of Mechanical, Wear Properties and Investigation on Microstructures, Applied Mechanics and Materials, 854, 2017, 115-120.

Prasanna S.C, Ramesh C, Property Evaluation of Aluminium Metal Matrix Composites Fabricated Using Stir Casting Method for Hand Lever In Automobile Applications, International Journal of Applied Engineering Research (IJAER), 10 (85), 2015.

Rajakumar S, Balasubramanian V, Balakrishnan M, Friction surfacing for enhanced surface protection of marine engineering components, erosion-corrosion study, Journal of the Mechanical Behavior of Materials, 25 (3-4), 2016, 111–119.

Rajakumar S, Muralidharan C, Balasubramanian V, Influence of Friction Stir Welding process and tool parameters on strength properties of AA7175-T6 aluminium alloy joints, Materials and design, 32, 2011, 535-549.

Ramesh C, Manickam C, Prasanna S.C, Lean Six Sigma Approach to Improve Overall Equipment Effectiveness Performance, A Case Study in the Indian Small Manufacturing Firm, Asian Journal of Research in Social Sciences and Humanities, 6 (12), 2016.

Ramesh C, Valliappan M, Prasanna S.C, Fabrication Of Ammcs By Using Stir Casting Method For Hand Lever, International Journal of New Technologies in Science and Engineering, 2 (1), 2015.

Ramesh M, Karthic KS, Karthikeyan T, Kumaravel A, Construction materials from industrial wastes—a review of current practices, International journal of environmental research and development, 2014, 317-324.

Ramesh M, Karthikeyan T, Effect of Reinforcement of Natural Residue (Quarry Dust) to Enhance the Properties of Aluminium Metal, Journal of Industrial Pollution Control, 2013.

Ramesh R, Ramesh C, Design, analysis and fabrication of canard wing configuration, International Journal of Research and Innovation in Engineering Technology, 2 (9), 2016.

Sethusundaram P.P, Arulshri K.P, Mylsamy K, Biodiesel blend, fuel properties and its emission characteristics Sterculia oil in diesel engine, International Review of Mechanical Engineering, 7 (5), 2013.

Threadgill P.L, Leonard A.J, Shercliff H.R, Withers P.J, Friction Stir Welding of aluminium alloys, Material Technology, 54, 2009, 49-93.

Vijayan V, Karthikeyan T, Design and Analysis of Compliant Mechanism for Active Vibration Isolation Using FEA Technique, International Journal of Recent Trends in Engineering, 1 (5), 2009.