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EFFECT OF MICROSTRUCTURE AND MECHANICAL PROPERTIES OF FRICTION STIR WELDED DISSIMILAR ALUMINIUM ALLOY JOINTS

Shaik Sulthan Parvaj[1], K. Satyanarayana[2]

[1]Student (PG), Department of Mechanical Engineering, SRKR Engineering College, Bhimavaram, W.G.D.T, Andhra Pradesh, India,
[2]Professor (ME), Department of mechanical Engineering, SRKR Engineering College, Bhimavaram, W.G.D.T, Andhra Pradesh, India.

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Abstract - *Friction Stir Welding (FSW) is a solid state welding process. In particular, it can be used to join high-strength aerospace aluminum and other metallic alloys that are hard to weld by conventional fusion welding. It was performed on 4mm thickness Al6061 and Al5083 dissimilar Aluminum alloys. Aluminum alloy light weight, softer, tendency to bend easily, cost effective in terms of energy requirements so aluminum alloy has selected in this FSW technique. In this welding when two metals are joined with the help of heat generated by rubbing metals against each other. The friction stir welding is mostly used for joining aluminum alloys. The main defects occurring in this welding are holes, material flow rate. These defects are mainly caused due to improper selection of welding parameters. In this project the mechanical properties of FSW dissimilar aluminum alloy Al5083 and Al6061 has tested with the help of universal testing machine, hardness testing by Vickers hardness at various zones of the welded joints. In this experimental the testing of mechanical properties based on the input parameters such as rotational speed, welding speed and offset angle with proper welding parameters. Finally, the experimental results will be compared with microstructures are analyzed by optical microscope.*

Key Words: *FRICTION STIR WELDING AL6061 AND AL5083 ALUMINIUM ALLOYS, TOOL ROTATIONAL SPEED, WELDING SPEED, MECHANICAL PROPERTIES, MICROSTRUCTURE.*

1. INTRODUCTION:

The Invention of friction stir welding is done at UK welding institute in 1991 and the process is solid state metal joining permanent process. Friction Stir welding is a new solid – state joining method offering several advantages over conventional welding methods, including better mechanical properties, low residual stress and reduced occurrence of defects. A rotating tool consisting of a shoulder and a probe is plunged into the joint and traversed along the joint line to form a weld. Fig-1 shows the schematic diagram of FSW. A typical friction stir weld consists of a thermo-mechanically effected zone which includes dynamically re-crystallized zone and the extensively deformed but not re-crystallized surrounding region, the heat affected zone and the unaffected base material AL6061&AL5083. The Process deals with two dissimilar metals. There is a significance to choose these materials as they are easily weldable, machinable good corrosion characteristics. AL6061 has good creep resistance and is a medium strength alloy.

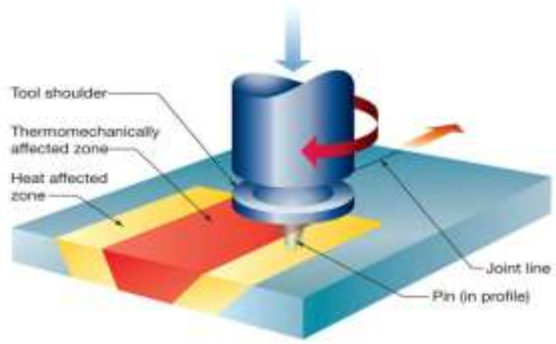

Fig 1.Schematic diagram of friction stir welding process

This alloy is ideal for high integrity casting operating at ambient temperatures or up to 300^0 F. The welds are created by the combined action of frictional heating and mechanical deformation due to a rotating tool. The maximum temperature reached is of the order of 0.8 of the melting temperature. The micro structure of friction stir welding depends in detail on the tool design, the rotation and translation speeds, the applied pressure and the characteristics of the material being joined. The effects of the process parameter are studied in this project.

2. EXPERIMENTAL WORK:

The experiment is performed on the vertical milling machine. Two plates of size 120*60*4mm were friction stir welded on vertical milling machine by designing a special fixture mounted on milling machine table.

2.1. SELECTION OF TOOL PROFILE AND WELDING PARAMETERS:

During the experimentation the parameters chosen are welding speed, tool rotation speed, and tool pin profile and feed rate. In the present investigation a cylindrical tool with tapered pin is used as shown in fig 2.

Fig2. Friction stir welding tool

2.2. Selection of Tool Material:

The material used for tool is H13 steel was used. The following are the type of material and its composition of H13 steel. The tool has a shoulder diameter of 20mm, pin diameter of 3mm and pin length of 3.7 mm. The rotating tool is specially designed such that the pin inserts into the abutting edges of plates to be joined and traversed along the line of joint, also the shoulder exerts external pressure and also generates enough heat from friction between the shoulder and work piece to form a strong joint. Chemical Composition of tool material is given in table1 below.

Table 1

Material	carbon	chromium	manganese	molybdenum	phosphorus
H13	0.32-4.5	4.75-5.5	0.2-0.5	1.1-1.75	0.03

3. EXPERIMENTAL PROCEDURE:

Initially a base metal of 4mm thickness of AL5083-AL6061 aluminum alloys was welded as but joint. These are welded under vertical milling machine having 1 HP motor and 3000 rpm. We have chosen H13 tool steel as it has Non-deforming characteristics and having high hot hardness. Specifications of tool shoulder and pin used are diameter of tool 20mm, diameter of the pin 3mm, and length of pin 3.7mm. A constant axial force of 5KN has been applied with four rotational and welding speeds. During FSW the welding and after welding the specimens were exposed to normal cooling (atmosphere or room temperature). After the completion of FSW specimens were cut for different tests (tensile test, compression test, micro hardness, and micro structure) as per ASTM standards. After weld specimens made they were go for test machines. Tensile specimens on universal testing machine, micro hardness on Vickers hardness machine, compression test on impact machine and microstructure on optical microscope was carried.

The schematic diagram of selection of samples for testing is shown in fig.3.1 and fig.3.2 After FSW, micro structural observations were carried out at the cross section of nugget zone of weldments normal to the FSP direction, mechanically polished and etched with Keller's reagent (2 ml HF, 3 ml HCl, 20 ml HNO3 and 175 ml H2O) by employing optical microscope (OM). Grain size is measured as per ASTM E112–13 standards.

The tensile test was conducted with the help of a computer controlled universal testing machine at a cross head speed of 0.5 mm/min. Micro hardness tests were carried out at the cross section of nugget zone by using Vickers digital micro hardness tester. The chemical composition of AL5083 and AL6061 are shown below.

Table 2

AL5083	AL6061
Si 0.4	Si 0.80
Fe 0.4	Fe 0.70
Cu 0.1	Cu 0.40
Mn 0.4-0.1	Mn 0.15
Mg 4.0-4.9	Mg 1.2
Cr 0.05-0.25	Cr 0.35
Zn 0.25	Zn 0.25
Ti 0.15	Ti 0.15
Al- Balance	Al- Balance

3.1 Process Parameters:

The following parameters considered for friction stir welding of Al5083 and AL6061 plates are rotational speed, transverse speed and offset angle which are shown table3 below.

Table 3

Specimen	Rotational Speed (rpm)	Welding Speed (mm/min)	Offset Angle (Degrees)
1.	710	30	0.0
2.	900	40	0.0
3.	1120	45	0.0
4.	1400	60	0.0

The friction stir welding of AL5083 and AL6061 plate and dimensions of test specimens like microstructure, micro hardness, and tensile tests are,

Fig 3.1 Aluminium alloy friction stir weldment

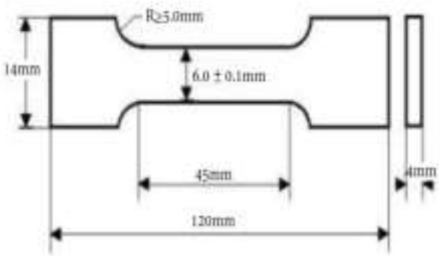

Fig 3.2 Schematic sketch of selection of sample for testing.

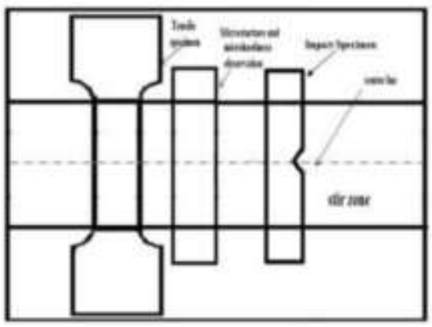

Fig 3.3 Schematic sketch of selection of sample for testing.

4. RESULTS AND DISCUSSIONS

4.1. Micro Structural Observation:

The micro structure was taken from each specimen from its WZ. The specimen's WZ was super finished by using various emery papers and finally taken it into mirror image. Then after we go for etching we use killer reagent (2mlHF, 3mlHCL, 20mlHNO3 and 175mlH2O) by optimal microscope as per ASTM E-112 standards. The optical microstructures of the weld center are shown in fig below. The grain arrangement within the nugget is well and equiaxed and the grain size significantly lesser than that in the base materials (5083) due to the advanced temperature and extensive plastic deformation by the stirring action of the tool probe. During FSW, the tool acts as a stirrer extruding the material along the welding path. Due to normal cooling the cooling rate of weldment was slower which impacts some uneven grains occur at some areas. The re-crystallization was strongly dependent on the rate of cooling and temperature. The fine grain size was obtained by circular tool with taper at welding parameters of 700 rpm and 30mm/min of tool rotation speed and welding speed respectively. The micro structures of specimens images was showed in fig 4.1, 4.2, 4.3, 4.4

Fig-4.1 Microstructure of specimen at 700rpm, 30mm/min.

Fig-4.2 Microstructure of specimen at 900rpm, 40mm/min.

Fig-4.3 Microstructure of specimen at 1120rpm, 45mm/min.

Fig-4.4 Microstructure of specimen at 1400rpm, 60mm/min.

4.2 Mechanical Properties:

Tensile samples were extracted from each joint. These samples were tested using universal testing machine (UTM) as per the ASTME 8-04 guidelines. The average of two readings is presented in Table 3. The results show that the tensile properties of the welded joints are significantly varied with regard to different rotational and transverse speeds. A higher tensile strength of 85.653Mpa was attained in the joint with rotational speed 1120rpm and transverse speed 45mm/min. A lower tensile strength of 38.659MPa was attained in the joint with rotational speed 900rpm and transverse speed 40mm/min. The percentage of elongation of welded joints was lower than that of the parent materials. The optimum proof stress was obtained by rotation speed 1120rpm and transverse speed 45mm/min with circular taper pin tool.

Table 4

Specimen	TENSILE PROPERTIES		
	Ultimate tensile Strength(Mpa)	% of Elongation	Yield Strength(Mpa)
1.	82.055	7.42	64.348
2.	38.659	2.80	34.037
3.	85.653	10.74	68.523
4.	74.839	4.88	65.91

4.3 VICKERS HARDNESS:

The Hardness properties of the specimens are carried under Vickers hardness testing machine as it is having diamond penetrator it is used to measure additional depth. We took 3 readings for each specimen and the average values of hardness in the welding center (NG) were placed against different tool rotation speed in Table-4. It was observed that when rotation speed raises hardness in the weldment drops. The optimum value of hardness was 44.73HVwhich was obtained by rotational speed 900rpm and transverse speed 40mm/min.

Table 5

Specimen	Hardness(HV)	Grain Size
1.	34.33	5.5
2.	44.73	4.5
3.	43.26	5.0
4.	38.00	3.5

5. CONCLUSION:

The butt joining of dissimilar aluminum alloy AL5083 and AL6061 was successfully carried out using friction stir welding (FSW) technique. Dissimilar metal joining process using friction stir welding is difficult to achieve because of different coefficient of heat and the base metal chemical composition and their property make it difficult to choose a proper welding parameters like rotating speed, traverse speed, axial force and tilt angle which plays a vital role in improving the weld quality. The microstructure and mechanical properties like tensile strength and micro hardness of these weld joints have been investigated.

As per my experiment review I will conclude that

- The optimum tensile and yield strength values 85.653Mpa and 68.523Mpa are obtained at rotational speed 1120rpm and weld speed 45mm/min.
- The optimum % of elongation 10.74 was obtained at same rotation speed 1120rpm and weld speed 45mm/min.
- The optimum hardness value 44.73 was obtained at rotational speed 900rpm and weld speed 40mm/min.

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REFERENCES:

[1]. Dr. K mallikarjuna Rao, Ch Mohana Rao, Studies on friction stir welding of aluminum alloys 6061-6061 similar metals. International journal of mechanical engineering and technology, volume 8, issue 1, January 2017, pp 264-269.

[2]. Buddi Manohar, Satishkumar. P, Aruri Deva Raju, Effect of microstructure and mechanical properties of friction stir welded dissimilar AA5083-AA6061 aluminum alloy joints. International journal of mechanical engineering and technology, Volume5, issue11, nov-2016.

[3]. Ramaraju Ramgopal Varma, Abdullah Bin Ibrahim, Mohammed, Arifpin Bin Mansor, Mechanical properties of the friction stir welded dissimilar aluminum alloy joints. International journal of mechanical engineering and technology, volume 2, issue 5, may 2014

[4]. D. Muruganandam, Friction stir welding process parameters for joining dissimilar aluminum alloys. International journal of mechanical engineering Volume 2 number 2, July- December (2011), pp. 25-38.

[5]. Ratnesh Kumar Raj Singh, "Effect of Friction Stir Welding on Mechanical Properties of Dissimilar Aluminum Alloys" National Conference on Innovative Paradigms in Engineering

& Technology (NCIPET-2012), Proceedings published by International Journal of Computer Applications (IJCA).

[6]. N Rajamanickam& V Balusamy, "Effects of process parameters on mechanical properties of friction stir welds using design of experiments" Indian Journal of Engineering & Materials Sciences. Vol. 15, August 2008, pp. 293-299.

[7]. S. Sattari, H. Bisadi, M. Sajed," Mechanical Properties and Temperature Distributions of Thin Friction Stir Welded Sheets of AA5083" International Journal of Mechanics and Applications 2012, 2(1): 1-6. DOI: 10.5923/j.mechanics.20120201.01.

[8]. S. Ravikumar, V. SeshagiriRao and R.V. Pranesh "Effect of Process Parameters on Mechanical Properties of Friction Stir Welded Dissimilar Materials between AA6061- T651 and AA7075-T651 Alloys", International Journal of Advanced Mechanical Engineering. Volume 4, Number 1 (2014), pp. 101-114.

[9]. D.Muruganandam and Dr.Sushil lal Das,, "Friction Stir Welding Process Parameters for Joining Dissimilar Aluminum Alloys", International Journal of Mechanical Engineering & Technology (IJMET), Volume 2, Issue 2, 2011, pp. 25 - 38, ISSN Print: 0976 – 6340, ISSN Online: 0976 – 6359.

[10]. N Rajamanickam & V.Baluswamy effect of process parameters and mechanical properties of friction stir welds using design of experiments. Indian journal of engineering & material science vol.15, August 2008,pp 293-299.

[11]. D. VENKATESWARLU, N.R.MANDAL, M.M.MAHAPATRA, and S.P.HARSH Tool Design Effects for FSW of AA7039 WELDING JOURNAL pp 41-47.