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Investigation on Mechanical Properties of Friction Stir Welded Aa6061-T6 & Aa7075

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ABSTRACT

AA6061 & AA7075 are used in the fabrication of bike parts, aerospace components and building constructions.The purpose of this work is experimentation, analysis and optimization of joining dissimilaraluminium alloy of AA6061 and AA7075 by Friction Stir Welding. The parameters like feed rate, spindle speed and axial force are the variables in the workand determine the mechanicalproperties like tensile strength, impact strength, hardness and microstructure properties like scanning electron microscope (SEM)and analyze the effect of weld parameters in the weld and have to study the material composition in the welded area.

KEYWORDS

Aluminium Alloys (AA6061 and AA7075), Friction Stir Welding (FSW), Mechanical Properties Like Tensile Strength, Impact Strength, Hardness and Scanning Electron Microscope (SEM).

Introduction

Quality and efficiency assumes a significant part in the present assembling market these days because of extremely hardened and relentless serious economic situation in assembling enterprises. The fundamental target of enterprises uncovers with creating better quality item at least conceivable expense and increment profitability. Welding is the most essential and basic activity utilized for joining of two comparable and divergent parts. AA6061 is widely used for fabrication purpose because it has the properties of good strength, formability, good corrosion resistance. AA7075 have the properties of very high strength, machinability and fair to reasonable corrosion resistance. Since 2xxx, 7xxx and 8xxx series are normally challenging are impossible to weld by fusion process. So Friction Stir Welding (FSW) is chosen for joining AA6061and AA7075. Friction Stir Welding (FSW) is a solid state joining process in which weld heat is produced by friction between the rotating spindle and the weld plate.FSW works by utilizing a non-consumable tool, which is pivoted and dove into the interface of two workpieces. The apparatus is then traveled through the interface and the frictional heat makes the material warm. The turning instrument at that point precisely blends the mollified material to deliver a strong state bond.

Friction Stir Welding

Friction Stir Welding (FSW) is a solid state joining process in which weld heat is produced by friction between the rotating spindle and the weld plate.FSW works by utilizing a non-consumable tool, which is pivoted and dove into the interface of two work pieces. The apparatus is then traveled through the interface and the frictional heat makes the material warm. The pin plunged into the work piece joint to form a strong bond between the work piece.

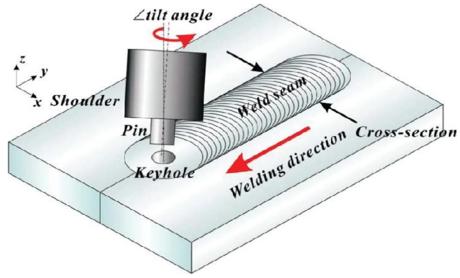

Figure 1. Friction Stir Welding

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The strength ofthe welding depends on following factors

- Feed Rate
- Spindle speed
- Maximum axial force

Aluminium Alloys

AA6061 is widely used for fabrication purpose because it has the properties of good strength, formability, good corrosion resistance. The Alloying composition of Aluminium 6061 is shown in (Table1)

Table 1. Chemical composition of Al6061

Elements	% of composition
Silicon	0.2-0.6
Iron	0.35
Copper	0.10
Manganese	0.10
Magnesium	0.45-0.9
Chromium	0.10
Zinc	0.10
Titanium	0.10
Aluminium	Remaining

AA7075 have the properties of very high strength, machinability and fair to reasonable corrosion resistance.The alloying element of Al7075 is shown in (Table2)

Table 2. Chemical composition of Al7075

Elements	% of composition
Silicon	0.08
Iron	0.3
Copper	1.5
Manganese	0.04
Magnesium	2.5
Zinc	5.6
Aluminium	Remaining

Experimental Procedure

The Aim of project research work is to perform a Friction Stir weld on dissimilar aluminium alloy of AA6061-T6 & AA7075 of various weld parameters and to find the optimum parameter by various tests such as Tensile, impact, hardness, Scanning Electron Microscope (SEM). In order to accomplish the main objectives following sequence of experimental work has been planned:

1. Cutting the different series of AA6061-T6 & AA7075 plates according to the weld dimensions (100x50x6)mm.
2. Fabrication of FSW joints by using hexagonal pin tool with various weld parameters(Feed Rate, Spindle speed, Maximum axial force).
3. Evaluation of tensile properties of AA6061-AA7075 joint.
4. Evaluation of impact behaviour of AA6061-AA7075 joint.
5. Characterization ofAA6061-AA7075 FSW joint using SEM and Hardness tests.

Figure 2. Welding of dissimilar Aluminium alloys

The above welded samples are made by changing the various welding process parameters. For each samples different feed rate, spindle rotational speed and axial force to be maintained. The various changes for each sample is shown in (Table 3).

Table 3. Welded samples process parameters

SI.NO	FEED RATE (mm/min)	TOOL ROTATIONAL SPEED (rpm)	MAXIMUM AXIAL FORCE (kN)
1.	15	1100	4
2.	20	1200	6
3.	25	1300	10

Experimental Tests on Welded Dissimilar Aluminium Alloy

In this work various weld parameters of FSWelded Aluminum alloy are examined by conducting the following tests.

- Tensile test by using UTM.
- Impact Test.
- Hardness Test with Rockwell Hardness Testing Machine.
- Microstructure analysis using SEM.

Tensile Test by Using UTM

Tensile testing is a basic materials science and engineering test that involves applying a controlled tension to a sample before it fails. The transverse tensile specimens were removed from the weld joints and tested on a servo-controlled universal testing system. According to ASTM handbook E8 M-04 guidelines, the specimen was loaded at a rate of 1.5 KN/min. To investigate the notch effect, smooth and notch tensile test specimens were developed. Figure 3 and 4 shows the specimens before and after tensile test.

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Figure 3. Test specimens before tensile test**Figure 4.** Test specimens after tensile test

Impact Test

The amount of energy consumed by a material during fracturing is measured by an impact test. This absorbed energy is a measurement of a material's hardness and can be used to investigate the temperature-dependent brittle-ductile transition. Its aim is to decide whether a material is brittle or ductile. Figure 3.10 shows the impact tester.
In impact test, depend upon the workpiece setup it is classified into two types,

1) Izod
2) Charpy

For our Impact test we choosed Izod test.

Figure 5. Specimens before test**Figure 6.** Specimens after test

Hardness Test (Rockwell Hardness)

The permanent depth of indentation formed by a force/load on an indenter is measured using the Rockwell process. Using a diamond or ball indenter, a preliminary test force (also known as preload or minor load) is applied to a sample. To minimise the effects of surface finish, this preload breaks through the surface.The baseline depth of

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indentation is determined after maintaining the preliminary test force for a given dwell period. Following the preload, an additional load known as the major load is added to achieve the total required test load. To allow for elastic recovery, this force is kept for a fixed period of time (dwell time). The main load is then released, and the preliminary load is resumed. The final depth of indentation is determined after keeping the preliminary test force for a given dwell period. The Rockwell hardness value is calculated by subtracting the baseline and final depth measurements. This measurement is converted into a hardness number. The preliminary test force is removed, as well as the indenter from the test specimen.

Scanning Electron Microscope(SEM)

A scanning electron microscope (SEM) is a type of electron microscope that uses a focused beam of electrons to scan the surface of a sample to produce images. Electrons interact with atoms in the sample, producing a variety of signals that contain information about the sample's surface topography and composition.An image is created by scanning the electron beam in a raster scan pattern and combining the position of the beam with the intensity of the detected signal. Secondary electrons emitted by atoms excited by the electron beam are detected using a secondary electron detector in the most common SEM mode (Everhart-Thornley detector).The number of secondary electrons that can be detected, and thus the signal intensity, is affected by specimen topography, among other things. Specimens are observed in high vacuum in a conventional SEM, or in low vacuum or wet conditions in a variable pressure or environmental SEM, as well as at a wide range of cryogenic or elevated temperatures using specialised instruments.

Results and Discussions

Tensile Test

The tensile result and stress strain curve for sample 1 is shown in (Fig 7).

Figure 7

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The tensile result and stress strain curve for sample 2is shown in (Fig 8).

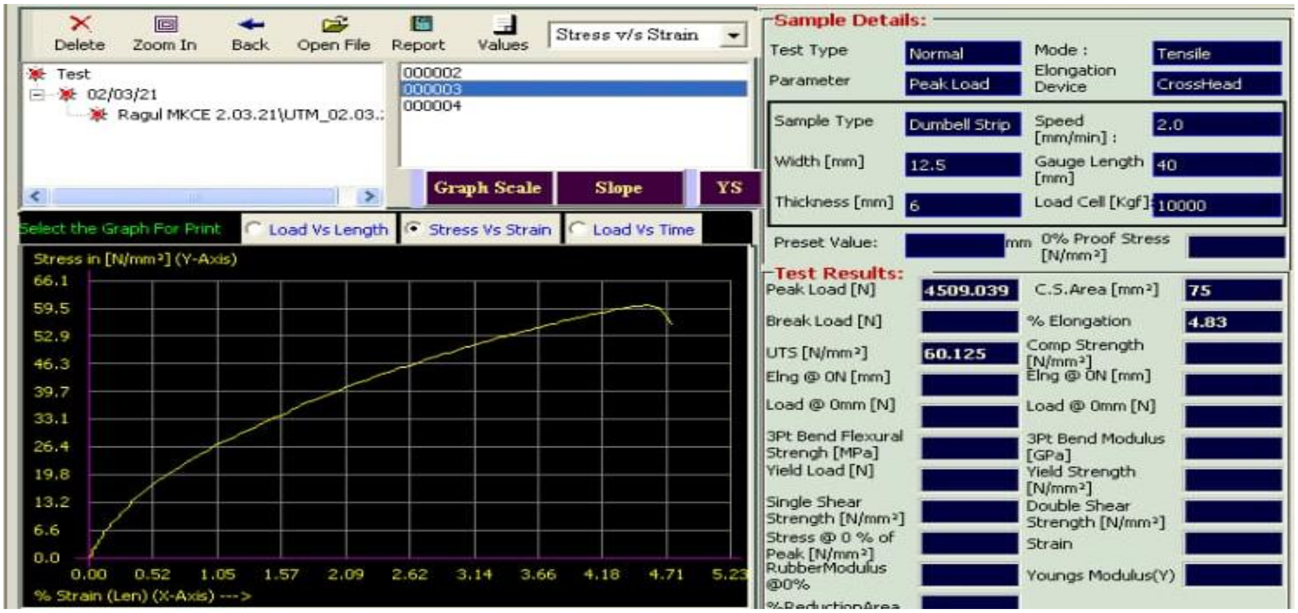

Figure 8

The tensile result and stress strain curve for sample 3 is shown in (Fig 9).

Figure 9

Impact Test

Table 4

Sample No.	Izod Impact values in J for 6mm thickness
1	7.20
2	14.5
3	14.4

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Hardness Test

RockwellHardness Testing:

- Ball intender size = 1/16 inch
- Load= 100 kgf

Hardness testBall intender (in hrp)

Table 5

S.NO	SAMPLE NUMBER	TRIAL 1	TRIAL 2	MEAN
1)	1	45	50	48
2)	2	37	45	41
3)	3	30	42	36

Microstructure Analyses

Figure 10, 11. SEM Images for Sample-1

Element	Weight%	Atomic%
C K	46.06	63.78
O K	9.91	10.30
Mg K	1.00	0.68
Al K	38.50	23.73
Si K	0.93	0.55
Cl K	0.13	0.06
K K	0.15	0.06
Ca K	0.11	0.04
Fe K	0.40	0.12
Cu K	0.49	0.13
Zn K	1.79	0.46
Ag L	0.52	0.08
Totals	100.00	

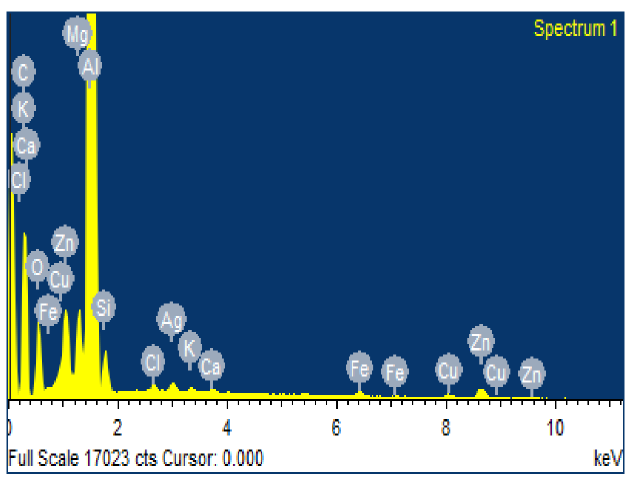

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Figure 12, 13. SEM Images for Sample-2

Element	Weight%	Atomic%
C K	34.78	52.52
O K	10.96	12.42
Mg K	1.27	0.95
Al K	48.47	32.58
Si K	0.54	0.35
Cl K	0.26	0.14
K K	0.13	0.06
Ca K	0.12	0.05
Cr K	0.15	0.05
Fe K	0.31	0.10
Cu K	0.52	0.15
Zn K	1.87	0.52
Ag L	0.61	0.10
Totals	100.00	

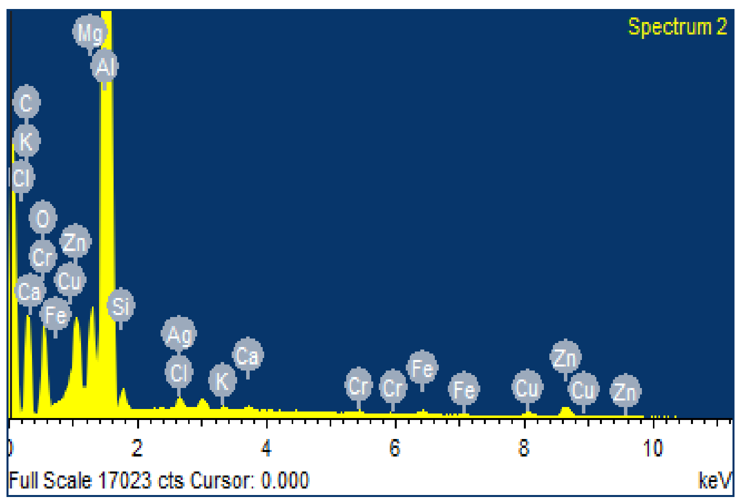

Figure 14, 15.SEM Images for Sample-3

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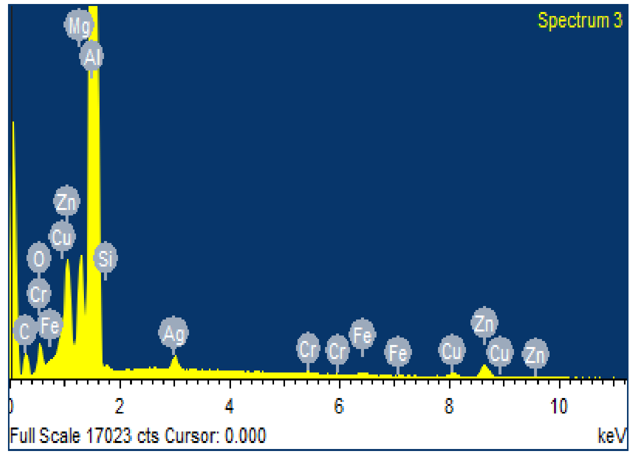
Element	Weight%	Atomic%
C K	14.85	28.20
O K	4.26	6.08
Mg K	1.76	1.65
Al K	73.51	62.12
Si K	0.25	0.20
Cr K	0.18	0.08
Fe K	0.25	0.10
Cu K	0.76	0.27
Zn K	3.04	1.06
Ag L	1.14	0.24
Totals	100.00	



Conclusion

- From the above graphs, in sample-1 during the test the peak load achieved at 2745.65N and the UTS is 36.61N/mm^2. Sample-2 achieves the peak load of 4509.03N and the UTS is 60.12N/mm^2. Sample-3 obtains the peak load of 2734.61N and the UTS is 36.46N/mm^2. Comparing these results, the Sample-2 withstands the maximum load and it has the higher tensile strength from these three samples.
- From the above results, The Sample-2 absorbs the maximum energy of 14.5J. So it has the more impact strength compared to the other two samples.
- From the above table, we can conclude that Sample-1 has maximum surface Hardness of 48 hrp.

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