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EXPERIMENTAL ANALYSIS OF WELD PARAMETERS FOR FRICTION STIR WELDING OF ALUMINIUM 6082

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Abstract - In this work welding of two aluminum plates will be done with a root gap of 0.25mm along with a speed of 1400 and 1800 rpm. After this we have changed root gap to 0.5mm and 0.75 mm along with the same speeds. After welding at these root gaps, the workpieces are investigated for different weld parameters. Here we will be doing Hardness test using Brinell Hardness Testing Machine and Vickers Hardness Testing Machine . After that weld parameters are tested for tensile strength using universal testing machine. We will examine the Microstructure behavior of Friction Stir Welded Aluminum 6082 with different root gaps and tool speeds.

Key Words: **Friction Stir Welding, Al 6082, Vickers Hardness Test, Brinell Hardness Test, Micro Structure Analysis.**

1.INTRODUCTION

Friction stir welding is a solid state welding process, is the newest addition to friction welding, a solid state welding process. Solid state welding, as the term implies, is the formation of joints n the solid state, without fusion. Solid state welding includes processes such as cold welding, explosion welding, ultrasonic welding, roll welding, forge welding.

There are different types of friction welding such as Rotary Friction Welding, Inertia Friction Welding, spin welding, friction surfacing,Friction Stud Welding, , Linear Friction Welding.

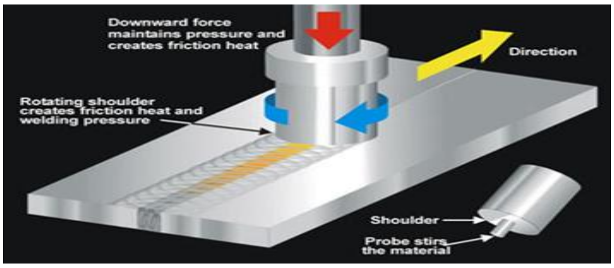


Fig 1. Friction Stir Welding

1. FRICTION STIR WELDING OF ALUMINUM 6082

1.1. Composition Of Aluminum 6082

The alloy composition of 6082 aluminum is

- Aluminum: 95.2 to 98.3%
- Chromium: 0.25% max
- Copper: 0.1% max
- Iron: 0.5% max
- Magnesium: 0.6 to 1.2%
- Manganese: 0.4% to 1.0%
- Silicon: 0.7 to 1.3% and Titanium: 0.1% max.

1.2 Properties of Aluminum 6082

Physical Properties

Density	:	2700 kg/m^3
Melting Point	:	555°C
Modulus Of Elasticity	:	70 GPa
Electrical Resistivity	:	0.038×10^{-6} Ω.m
Thermal Conductivity	:	180 W/m.K
Thermal Expansion	:	24×10^{-6} /K

Fig 1.1. Aluminum 6082 Plates Ready For Friction Stir Welding.

Fig 1.2. Shoulder Shaped tool used For Friction Stir Welding.

2. FRICTION STIR WELDING METHODOLOGY

Friction stir welding is done on the 6 specimens of Aluminum 6082 by the following root gaps with different rpm's.

Fig 2.1. Friction Stir Welded Aluminum 6082 With 0.25mm root gap at 1400 rpm

Fig.2.2. Friction Stir Welded Aluminum 6082 With 0.5mm root gap at 1400 rpm

Fig.2.3. Friction Stir Welded Aluminum 6082 With 0.75mm root gap at 1400 rpm

Fig.2.4. Friction Stir Welded Aluminum 6082 With 0.25mm root gap at 1800 rpm

Fig.2.5. Friction Stir Welded Aluminum 6082 With 0.5mm root gap at 1800 rpm

Fig.2.6. Friction Stir Welded Aluminum 6082 With 0.75mm root gap at 1800 rpm

3. EXPERIMENTAL TESTS ON FSW 6082

In this work various weld parameters of friction stir welded Aluminum 6082 are examined by conducting the following tests.

- Hardness Test with Vickers Hardness Testing Machine and Brinell Hardness Testing Machine
- Micro Structure Analysis

3.1 Brinell Hardness Test

The Brinell hardness test method as used to determine Brinell hardness, is defined in ASTM E10. Most commonly it is used to test materials that have a structure that is too coarse or that have a surface that is too rough to be tested using another test method, e.g., castings and forgings. Brinell testing often use a very high test load (3000 kgf) and a 10mm wide indenter so that the resulting indentation averages out most surface and sub-surface inconsistencies

An iron ball of tempered steel or a hard metal ball with a known diameter is pressed vertically with a test force F in an isolated testing surface. Test force is exerted during a defined time (from 2 to 8 seconds); incidence time must be from 10 to 15 seconds. Brinell hardness is calculated by the pressure diameter and the test force. The hardness measurement developed by Brinell is used for soft and medium hard metals, non-alloyed construction grade steel, aluminium, wood and work materials with irregular structures such as cast iron. An iron ball or one made of a hard metal is struck with a defined force for measurement against the surface of the material.

Fig.3.1. Brinell Hardness Testing

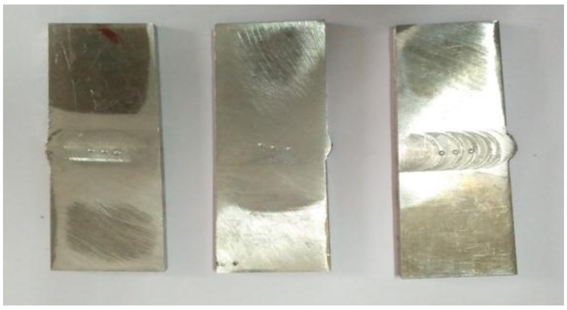


Fig.3.2. Hardness test indentations on work piece

3.2 Vickers Hardness Test

The Vickers hardness test method consists of indenting the test material with a diamond indenter, in the form of a right pyramid with a square base and an angle of 136 degrees between opposite faces subjected to a load of 1 to 100 kgf. The full load is normally applied for 10 to 15 seconds. The two diagonals of the indentation left in the surface of the material after removal of the load are measured using a microscope and their average calculated.

The area of the sloping surface of the indentation is calculated. The Vickers hardness is the quotient obtained by dividing the kgf load by the square mm area of indentation. The Vickers hardness test measures hard work materials but also the hardness of materials and thin walls or marginal areas.

Fig.3.3. Vickers Hardness Testing Machine

Hardness test will be carried out on the following samples.

1. Friction Stir Welded aluminum 6082 with root gap of 0.25mm at tool speed 1400

2. Friction Stir Welded aluminum 6082 with root gap of 0.5mm at tool speed 1400

3. Friction Stir Welded aluminum 6082 with root gap of 0.75mm at tool speed 1400

4. Friction Stir Welded aluminum 6082 with root gap of 0.25mm at tool speed 1800

5. Friction Stir Welded aluminum 6082 with root gap of 0.5mm at tool speed 1800

6. Friction Stir Welded aluminum 6082 with root gap of 0.75mm at tool speed 1800 .

4. TENSILE TEST

Tensile Test is done with Universal Testing machine for examining the Variation of Ultimate Tensile Strength of Friction Stir Welded Aluminum 6082 with different root gaps and at different tool speeds. i.e., Tensile test will be carried out on the following samples.

1. Friction Stir Welded aluminum 6082 with root gap of 0.25mm at tool speed 1400

2. Friction Stir Welded aluminum 6082 with root gap of 0.5mm at tool speed 1400

3. Friction Stir Welded aluminum 6082 with root gap of 0.75mm at tool speed 1400

4. Friction Stir Welded aluminum 6082 with root gap of 0.25mm at tool speed 1800

5. Friction Stir Welded aluminum 6082 with root gap of 0.5mm at tool speed 1800

6. Friction Stir Welded aluminum 6082 with root gap of 0.75mm at tool speed 1800

Fig. 4.1. Universal Testing Machine

Fig.4.2. Tensile Test Specimens

5. MICRO STRUCTURE ANALYSIS

Microstructure analysis is the structure of material is studied under magnification.

Microstructure is the small scale structure of a material, defined as the structure of a prepared surface of material as revealed by a microscope above 25× magnification The microstructure of a material can strongly influence physical properties such as strength, toughness, ductility, hardness, corrosion resistance, high/low temperature behavior or wear resistance. These properties in turn govern the application of these materials in industrial practice. Microstructure at scales smaller than can be viewed with optical microscope.

Fig.5.1. optical microscope

The Microstructure analysis is done to find the variation in the microstructure of Aluminum 6082 with Friction Stir welding with different root gaps and at different tool speeds. Analysis will be conducted on the following samples.

1. Friction Stir Welded aluminum 6082 with root gap of 0.25mm at tool speed 1400

2. Friction Stir Welded aluminum 6082 with root gap of 0.5mm at tool speed 1400

3. Friction Stir Welded aluminum 6082 with root gap of 0.75mm at tool speed 1400

4. Friction Stir Welded aluminum 6082 with root gap of 0.25mm at tool speed 1800

5. Friction Stir Welded aluminum 6082 with root gap of 0.5mm at tool speed 1800

6. Friction Stir Welded aluminum 6082 with root gap of 0.75mm at tool speed 1800.

Fig.5.2. Microstructure observation of specimen under optical microscope

5.RESULTS AND DISCUSSIONS

5.1 Brinell Hardness Test Values

Hardness Testing Parameters

Type of Hardness test	:	BHN
Type of Material	:	AL 6082
Dimensions	:	100*60*5
Size of Intender	:	5 mm
Load applied	:	250 KgS

SPEED	ROOT GAP	BRINELL HARDNESS			
		IMP 1	IMP 2	IMP3	IMP 4
1400	0.25	62.4	61.8	61.2	61.80
	0.5	60.4	60.1	59.5	60.00
	0.75	57.3	57.9	58.4	57.87
1800	0.25	63.0	63.6	64.2	63.60
	0.5	62.4	61.8	61.2	61.80
	0.75	59.5	60.1	60.6	60.07

Table:5.1 Brinell Hardness Test Values

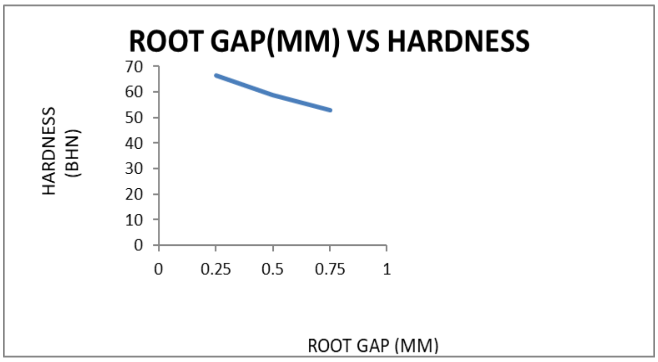
5.2 Vickers Hardness Test Values

Hardness Testing Parameters

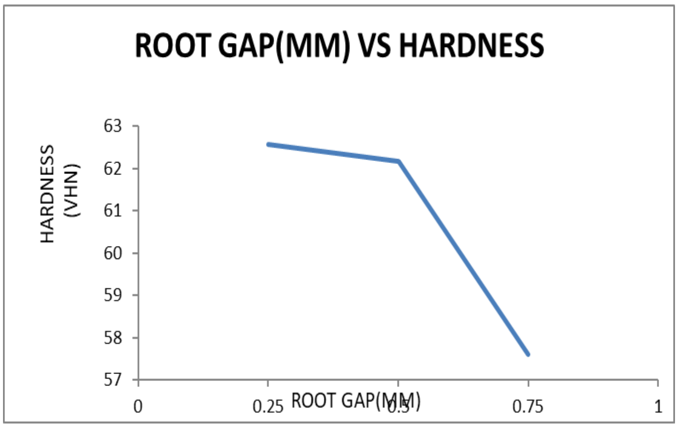
Type of Hardness test	:	VHN
Type of Material	:	AL 6082
Dimensions	:	100*60*5
Type of Intender	:	Diamond
Load applied	:	5 Kgs

SPEED	ROOT GAP	VICKERS HARDNESS			
		IMP 1	IMP 2	IMP3	IMP 4
1400	0.25	67.0	66.6	66.3	66.63
	0.5	58.0	60.0	58.3	58.77
	0.75	52.1	53.3	52.8	52.73
1800	0.25	63.2	62.6	61.9	62.57
	0.5	61.6	62.3	62.6	62.17
	0.75	58.0	57.7	57.1	57.60

Table:5.2 Vickers Hardness Test Values



Graph 5.1 Variation of hardness with root gap at 1400 rpm

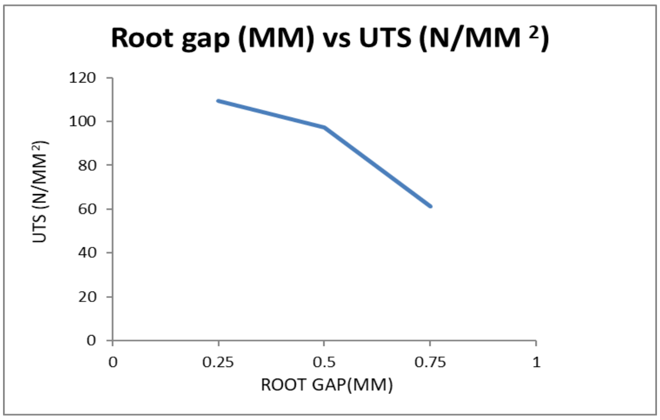


Graph 5.2 Variation of hardness with root gap at 1800 rpm

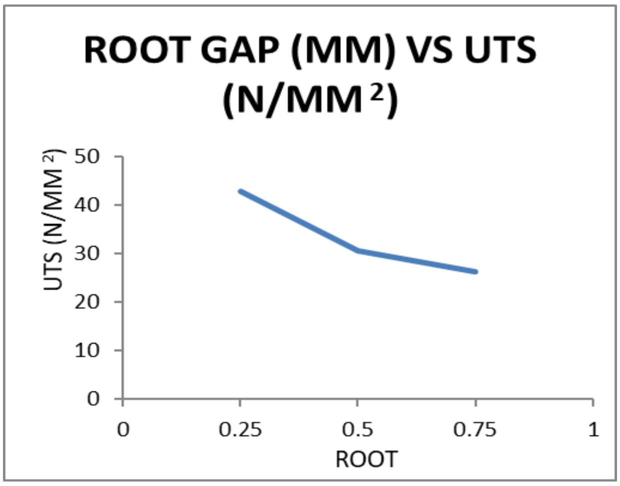
5.3.Tensile Test Values

SPEED	ROOT GAP	TENSILE TEST READINGS				
		UTL	UTS N/MM 2	YIELD (%)	YIELD LOAD Kn	YIELD STRENGTH N/MM2
1400	0.25	8.240	109.182	3.540	4.960	65.721
	0.5	7.080	97.346	2.500	5.680	78.097
	0.75	4.120	61.028	1.160	3.120	46.215
1800	0.25	3.120	42.804	3.780	2.200	30.187
	0.5	1.920	30.573	3.640	1.880	29.936
	0.75	1.840	26.320	1.760	1.400	20.026

Table 5.3. Overall Tensile Test Readings with different root gaps at different speeds



Graph 5.3: variation of ultimate tensile strength values with root gap at 1400 rpm



Graph 5.4: variation of ultimate tensile strength values with root gap at 1800 rpm

5.4 Microscope Test report

Fig.:5.3 Grain Size of 0.25 root gap specimen at 1400 rpm

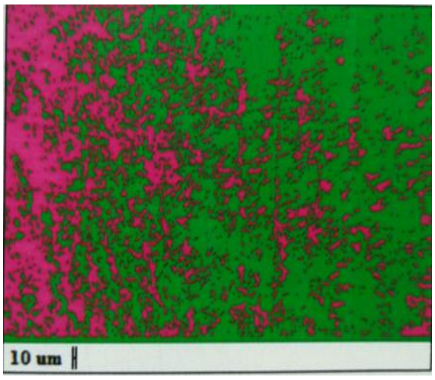


Fig.:5.4 Heat affected zone of 0.25 root gap specimen at 1400 rpm

Fig.:5.5 Grain size of 0.5 root gap specimen at 1400 rpm

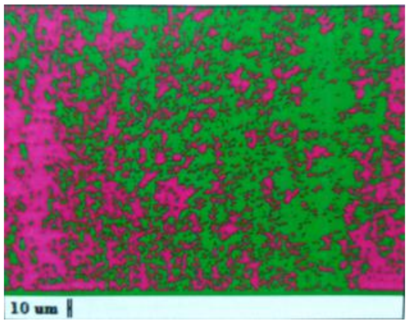


Fig.:5.6 Heat affected zone of 0.5 root gap specimen at 1400 rpm

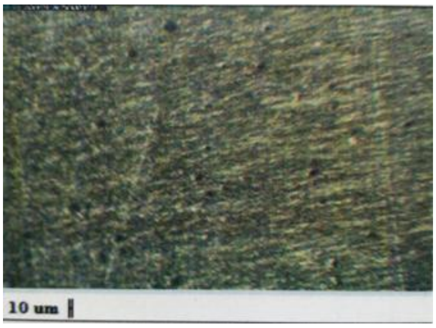


Fig.:5.7 Grain Size of 0.75 root gap specimen at 1400 rpm

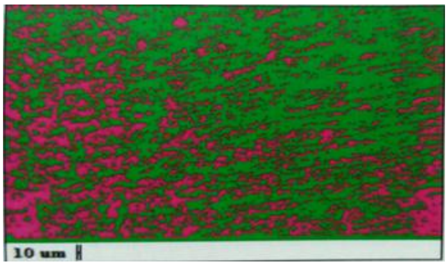


Fig.:5.8 Heat affected zone of 0.75 root gap specimen at 1400 rpm

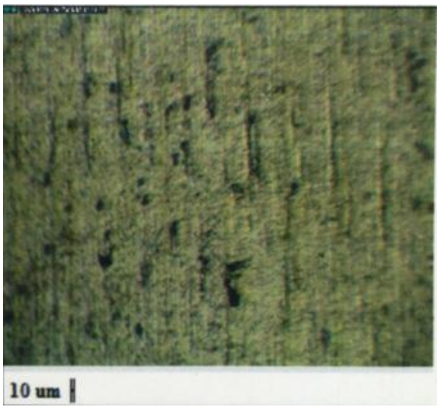


Fig.:5.9 Grain Size of 0.25 root gap specimen at 1800 rpm

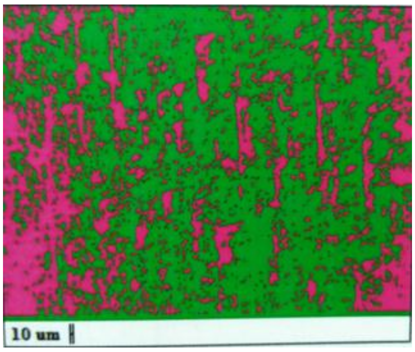


Fig.:5.10 Heat affected zone of 0.25 root gap specimen at 1800 rpm

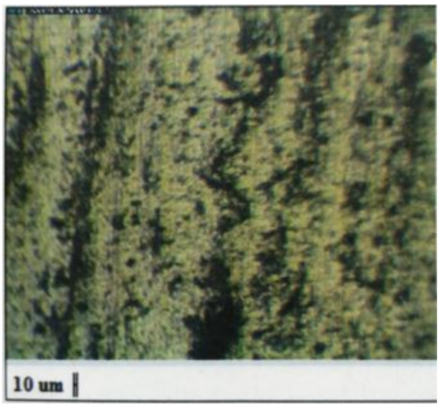


Fig.:5.11 Grain Size of 0.5 root gap specimen at 1800 rpm

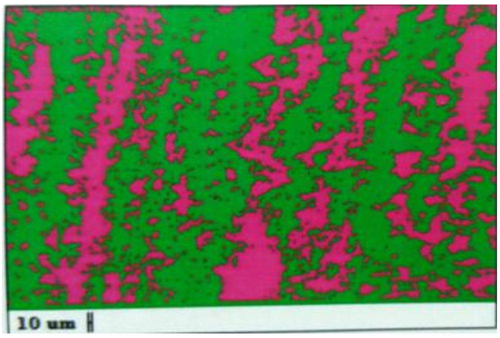


Fig.:5.12 Heat affected zone of 0.5 root gap specimen at 1800 rpm

Fig.:5.13 Grain Size of 0.75 root gap specimen at 1800 rpm

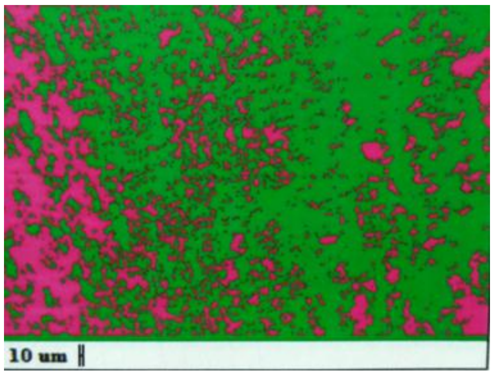


Fig.:5.14 Heat affected zone of 0.75 root gap specimen at 1800 rpm

6. CONCLUSIONS

From the previous chapter results following conclusions can be made for FSWAL6082.

1. The Hard ness of the Friction stir welded AL6082 will decrease with the increment in root gap from 0.25 mm to 0.75 mm.

2. The Hard ness of the Friction stir welded AL6082 will decrease with the increment in spinning tool speed from 1400 rpm to 1800 rpm.

So we can conclude that it can be suggested to opt friction stir welding of AL6082 with less root gaps and welding should be done at low spinning tool speed to get required weld quality with improved weld properties like Hardness, Ultimate tensile strength, Microstructure etc.

3. The Ultimate tensile strength of the Friction stir welded AL6082 will decrease with the increment in root gap from 0.25 mm to 0.75 mm.

4. The Ultimate tensile strength of the Friction stir welded AL6082 will decrease with the increment in spinning tool speed from 1400 rpm to 1800 rpm.

5. The Microstructure variation is more with more heat affected zones(HAZs) of the Friction stir welded AL6082 with the increment root gap from 0.25 to 0.75 mm.

6. The Microstructure variation is more with more heat affected zones(HAZs) of the Friction stir welded AL6082 with the increment in spinning tool speed from 1400 rpm to 1800 rpm.

So, we can conclude that it can be suggested to opt friction stir welding of AL6082 with less root gaps and welding should be done at low spinning tool speed to get required weld quality with improved weld properties like Hardness, Ultimate tensile strength, Microstructure etc.

6.1.FUTURE SCOPE:

Future work on Friction stir welding can be carried out and weld parameters can be investigated for similar (or) dissimilar metals by considering the influence of various other parameters like Deformation characteristics of the metal, Angle of tool, Pressure applied by the spin tool etc.

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