IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 12, Issue 2 Ver. VI (Mar - Apr. 2015), PP 143-147
www.iosrjournals.org

Analysis Of Mechanical Properties On Friction Stir Welded Aluminium Alloy (AA6063) Plate

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Abstract: *Friction stir welding (FSW) is a solid state joining process that uses friction generated by a rotating cylindrical tool which produces heat and plasticize metal on either side of a joint, creating a solid functional weld. Friction- generated heat is more effective at reorganizing the microstructure of metals and metal alloys than other forms of fusion welding. This joining technique is energy efficient, environment friendly, and versatile. In particular, it can be used to join high-strength aerospace Aluminium alloys and other metallic alloys that are hard to weld by conventional fusion welding. FSW is considered to be the most significant development in metal joining in a decade. A comparison is made on Fusion welding (metal inert gas arc welding) and frictional stir welding through various mechanical testing method. They were tested for mechanical properties such as tensile strength and Rockwell hardness respectively. It was found that the mechanical properties of the friction stir welded Aluminium alloy plate were superior than the MIG arc welded Aluminium alloy plate.*

Keywords: *Friction Stir welding (FSW), Metal Inert Gas Arc welding (MIG), AA6063 Aluminium alloy, Tensile Strength, Rockwell Hardness.*

I. Introduction

Compared to many of the fusion welding processes that are routinely used for joining structural alloys, friction stir welding (FSW) is an emerging solid state joining process in which the material that is being welded does not melt and recast. Friction stir welding (FSW) was invented at The Welding Institute (TWI), UK in 1991. Friction stir welding is a continuous, hot shear, autogenously process involving non-consumable rotating tool of harder material than the substrate material. Defect free welds with good mechanical properties have been made in a variety of aluminium alloys. When alloys are friction stir welded, phase transformations that occur during the cool down of the weld are of a solid state type in which a rotating tool moves along the joint interface, generating heat and resulting in a re-circulating flow of plasticized material near the tool surface. This plasticized material is subjected to extrusion by the tool pin rotational and traverse movements leading to the formation of the so called stir zone. Cavaliere et all (2005) is reported as The aim of the present work is to investigate on the mechanical and micro structural properties of dissimilar 2024 and 7075 aluminium sheets joined by friction stir welding (FSW). The two sheets, aligned with perpendicular rolling directions, have been successfully welded; successively, the welded sheets have been tested under tension at room temperature in order to analyze the mechanical response with respect to the parent materials. The fatigue endurance (S–N) curves of the welded joints have been achieved, since the fatigue behavior of light welded sheets is the best performance indicator for a large part of industrial applications; a resonant electro-mechanical testing machine load and a constant load ratio RZsmin/smaxZ0.1 have been used at a load frequency of about 75 Hz. The resulted microstructure due to the FSW process has been studied by employing optical and scanning electron microscopy either on 'as welded' specimens and on tested specimen after rupture occurred. Elangovan and Balasubramanian (2 0 0 8) AA2219 is reported as aluminium alloy has gathered wide acceptance in the fabrication of light weight structures requiring a high strength to weight ratio. The welding parameters and tool pin profile play major roles in deciding the weld quality. Liechty and Webb (2008) is reported as Material flow and frictional heating in friction stir welding are investigated using a three-dimensional numerical model. Two mechanical boundary conditions are investigated, including a sticking constant velocity and a slipping variable shear stress model. For the constant velocity model, material in contact with the tool is set at a velocity equal to some fraction of the tool rotational speed. The limited deformation, low velocities, and suggestion of void formation agree well with flow visualization studies using plasticize under identical operating parameters.

II. Experimental Set Up

The friction stir welding set up is shown in fig.1. A non-consumable rotating tool with a specially designed pin and shoulder is inserted into the abutting edges of sheets or plates to be joined and traversed along the line of joint (Fig.2). The tool serves two primary functions: (a) heating of work piece, and (b) movement of material to produce the joint. The heating is accomplished by friction between the tool and the work piece and plastic deformation of work piece. The localized heating softens the material around the pin and combination of tool rotation and translation leads to movement of material from the front of the pin to back of the pin.

Fig.1 Friction stir welding process set up

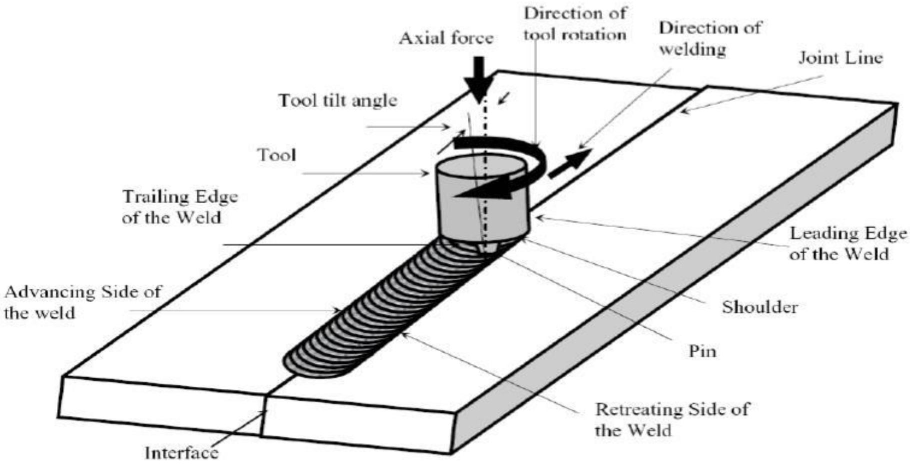

Fig.2 Schematic diagram of friction stir welding.

III. Process Parameter

The process parameter for the friction stir welding process is shown in table.1

Table.1 Process parameter

Rotational Speed(rpm)	800
Welding Speed(mm/min)	20
Axial Force(KN)	9.5

Tool pin geometry is shown in fig.3.

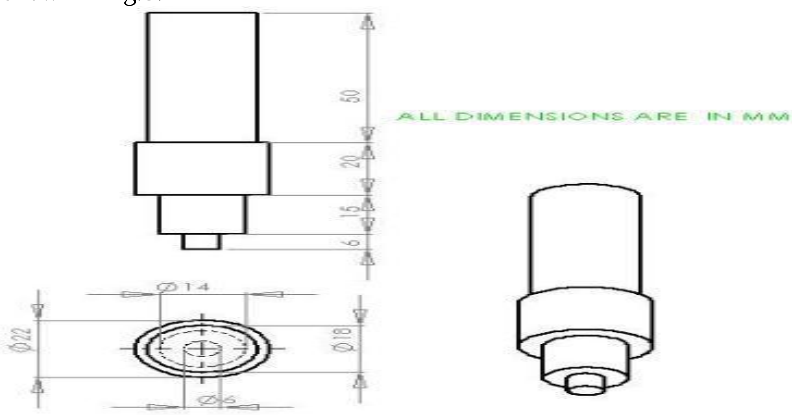

Fig.3. Geometry of the tool pin

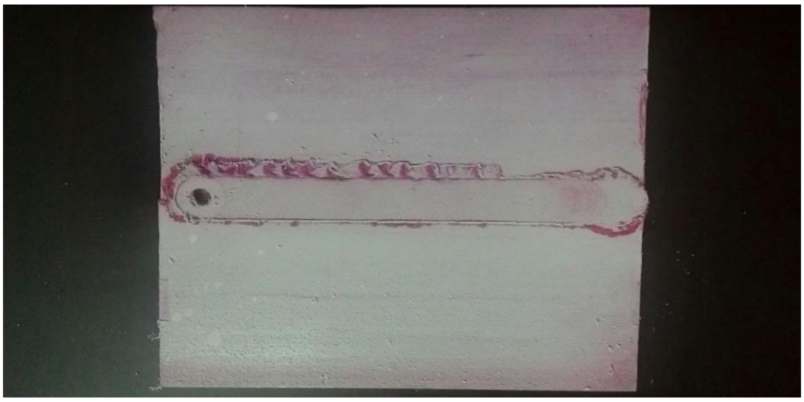

Fig.4. FSW Aluminium 6063 plate

The friction stir welded (FSW) Aluminium alloy 6063 welded plate is shown in fig.4. The flat plates of 6.3mm thickness, AA6063 aluminum alloy, have been cut into the required size (100mm×70mm) by power hacksaw cutting and milling. The initial joint configuration is obtained by securing the plates in position using mechanical clamps. The direction of welding is normal to the rolling direction. Single pass welding procedure has been used to fabricate the joints. Square butt join has been prepared to fabricate FSW joints. No special treatment was carried out before welding and testing. Non consumable tools made of high speed steel have been used to fabricate the joints. An indigenously designed and developed machine (15 hp; 3000 rpm; 25 KN) has been used to fabricate the joints. The above mentioned geometry of tool pin profile and process parameters have been used to fabricate the joints.

IV. Results And Discussions

4.1 Analysis of Tensile strength of the Friction stir welded Aluminium alloy 6063 plate over MIG welded Aluminium alloy 6063 plate

The welded joints are sliced using power hacksaw and then machined to the required dimensions to prepare tensile specimen American Society for Testing of Materials (ASTM E8M-04) guidelines is followed for preparing the test specimens. Tensile test has been carried out in 100 kN, electro-mechanical controlled Universal Testing Machine. The specimen is loaded at the rate of 1.5 kN/min as per ASTM specifications, so that tensile specimen undergoes deformation. The specimen finally fails after necking and the load versus displacement has been recorded. The 0.2% offset yield strength, ultimate tensile strength and percentage of elongation have been evaluated for both FSW and MIG welded aluminium alloy plate. The Fig.5 shows the MIG welded and FSW plate aluminium alloy tensile test specimen.

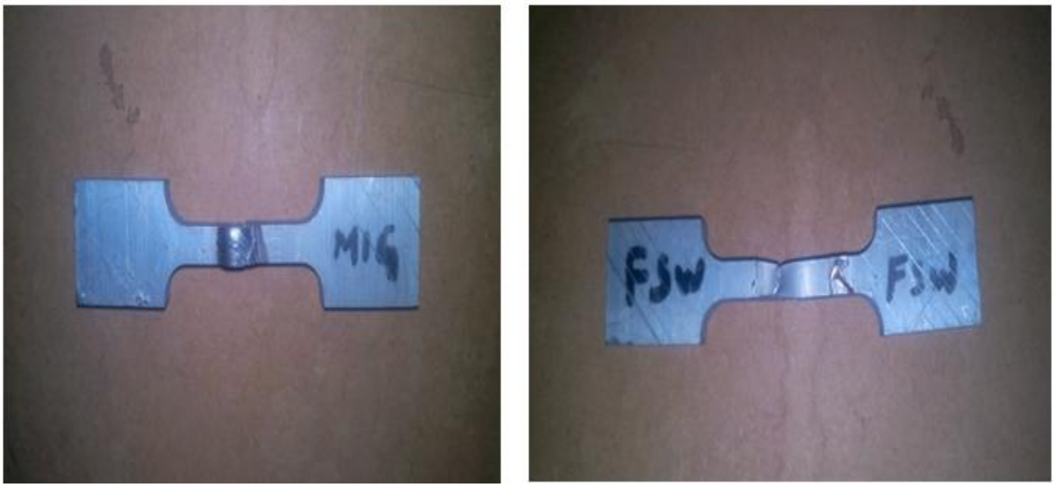

Fig.5. MIG and FSW welded plate Aluminium alloy tensile test specimen.

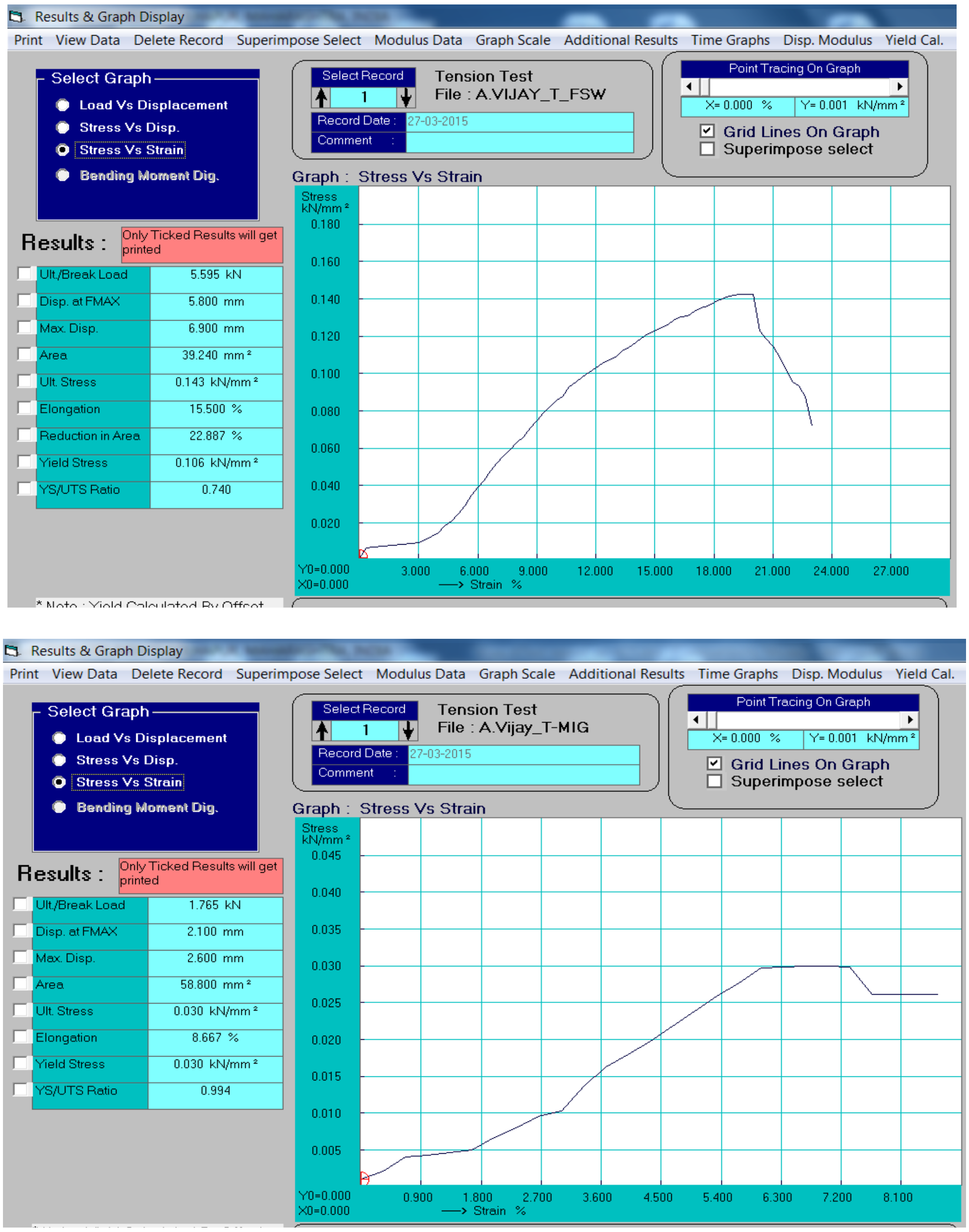

Fig.6 Stress – Strain curve for FSW and MIG welded plate Tensile test report

Tensile test report for both the FSW specimen and MIG specimen has been obtained from electronically generated Stress Strain curve (Fig.6). The below Table.2 Values are obtained from the Stress Strain curve, generated during Tensile test of the both the specimen.

Table.2 Comparison between FSW and MIG welded plate tensile test result

	FRICTIONAL STIR WELDING	METAL INERT GAS WELDING
Ultimate/Break Load	5.595 KN	1.765 KN
Display of Fmax	5.800 mm	2.100 mm
Max. Display	6.900 mm	2.600 mm
Area	39.240 mm^2	58.800 mm^2
Ultimate stress	0.143 KN/mm	0.030 KN/mm
Elongation	15.500%	8.667%
Yield stress	0.106 KN/mm^2	0.030 KN/mm^2
Yield stress, UTS Ratio	0.740	0.944

The tensile strenth result has been obtained from Table.2. It has been found and observed that the FSW welded plates gives more tensile strength than MIG welded plates.

4.2 Analysis of Rockwell hardness of the Friction stir welded Aluminium alloy 6063 plate over MIG welded Aluminium alloy 6063 plate

Both FSW and MIG welded AA6063 plate were produced. The specimens were made from the welded plates and they were tested for hardness in the Rockwell hardness tester. The values of the Rockwell hardness exhibited by both welding process were given in the Table.3

Table.3. Rockwell hardness of the FSW and MIG welded Plates

SL.NO	Material	Load in Kgf	Indenter (steel Ball) mm	Scale	Trial No:			Rockwell Hardness Value (HRB)
					1	2	3	
1	Aluminium (FSW)	60	1.588	B	45	47	52	48
2	Aluminium (MIG)	60	1.588	B	44	42	43	43

It was observed from the Table.3 that the hardness value for the FSW Aluminium plate is more superior to the MIG welded Aluminium plate.

V. Conclusion

In this research, two AA6063 Aluminium welded plate is produced by both Friction stir welding process and Metal Inert gas arc welding process. It was observed that the mechanical properties such as tensile strength and Rockwell hardness were superior in the Friction Stir welded AA6063 plate than Metal inert gas arc welded AA6063 plate. Thus Friction stir welding technology has the potential to play an important role in the near future for improving the quality of the engineering components.

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