Comparitive Static Analysis Using Finite Element Techniques for Lap and Butt Welded Joints

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COMPARITIVE STATIC ANALYSIS USING FINITE ELEMENT TECHNIQUES FOR LAP AND BUTT WELDED JOINTS

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Abstract. Friction Stir Welding is a solid-state welding technique, using which we can attain welds with reduced distortion and improved mechanical properties in similar as well as dissimilar metals. Various properties of metals and their alloys are analyzed to choose the best combination of metals that can effectively create lap and butt joints. In this study Aluminium (Al) and Magnesium (Mg) are chosen as dissimilar metals due to their wide spread applications. The welds are designed and analyzed based on the effect Tensile stress, Shear stresses and deformation by using simulation software and comparing the results with practically obtained Tensile and Shear Stress Values tested on Universal testing machine. In this study, using Friction Stir Welding technique lap and butt joints are made which are subjected to the structural analysis were analyzed using CAD and CAE software.

Keywords: Aluminium, Magnesium, Friction Stir Welding, Dissimilar metals, Lap Joint, Butt Joint, CAD and CAE software.

1 Introduction

Friction Stir Welding is a solid-state process, which means that the objects are joined without reaching melting point. This opens up whole new areas in welding technology. Using FSW, rapid and high quality welds of 2xxx and 7xxx series alloys, traditionally considered non-weldable, are now weldable. In friction stir welding process, the parts are subjected to relative motion under pressure so that the frictional heat developed at the interface between faying surfaces, is utilized to join similar or dissimilar metals. Such bonds are permanent, having strength approaching that of the base metals used. All thermoplastic materials can be friction welded including crystalline and amorphous material, with no additional weight. This process is easily controllable, repeatable, reliable, and is a simple machine tool technology which is having similar benefits like other solid phase welding processes. Heat affected zone is less and hence post weld treatment is not normally required to relieve internal stresses. The deposit obtained has excellent metallurgical bond with forged microstructure. The deposit is free from porosity, slag inclusions or dilutions which are generally experienced in traditional fusion welding processes. The process itself is environmentally clean, with no fumes, spatter or high intensity light emissions as in laser-based coating methods, hence it also termed as green manufacturing technology. This process can be performed in open air, with inert gas or under water. It is also energy efficient because the heat is generated and used exactly where it is needed. Bond strength is very good and these deposits are expected to serve better during service life. Friction stir welding was invented by The Welding Institute (TWI) in December 1991. TWI filed successfully for patents in Europe, the U.S., Japan, and Australia. TWI then established TWI Group-Sponsored Project 5651,"Development of the New Friction Stir Technique for Welding Aluminium," in 1992 to further study this technique. The development project was conducted in three phases. Phase I proved FSW to be a realistic and practical welding technique, while at the same time addressing the welding of 6000 series aluminium alloys. Phase II successfully examined the welding of aerospace and ship aluminium alloys, 2000 and 5000 series, respectively. Process parameter tolerances, metallurgical characteristics, and mechanical properties for these materials were established. Phase III developed pertinent data for further industrialization of FSW. In the present paper design and analysis is carried out using CATIA and ANSYS software comparing the results obtained with practical experimentation.

2 Experimentation

Two base metals of Aluminum-AA5083 and Magnesium- AZ31B of dimensions 100x75x4mm are used. The H13 non consumable mechtrode is used to perform the friction stir processing. A Tool rotational speed of 560 rpm and horizontal feed 25mm/min were employed Lap Weld: Figure(1) For this type of joint both the joints are held tight & plates are placed one over other. The rotating tool at a constant rotational and translation velocity with sufficient downward force is moved across the work piece. The tool used for lap joints has much longer pin then that is used for a butt joint since it has to penetrate both the sheets for proper stirring action. Butt Joint: Figure(2) For this type of joint both the joints are held tight with the adjoining edges against each other. The rotating tool at a constant rotational and translation velocity with sufficient downward force is moved across the work piece. The butt joint is formed with the same specifications of milling machine as of the lap joint; Here butt joint is formed instead of lap. The tool is fed on the adjoining plates with the help of milling machine.

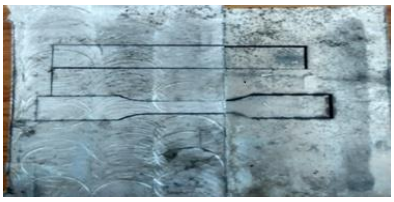

Fig 1. Lap Weld

Fig 2. Butt Weld

Electrical discharge machining (EDM), sometimes colloquially also referred to as spark machining, spark eroding, burning, die sinking, wire burning or wire erosion, is a manufacturing process whereby a desired shape is obtained using electrical discharges (sparks). Material is removed from the work piece by a series of rapidly recurring current discharges between two electrodes, separated by a dielectric liquid and subject to an electric voltage. One of the electrodes is called the tool-electrode, or simply the "tool" or "electrode", while the other is called the work piece-electrode, or "work piece". Structural analysis of the lap and butt joints of the base metals of Aluminum-AA5083 and Magnesium- AZ31B are carried out on the Universal Testing Machine(UTM) after the weld. A graphical data is shown below for the test conducted on UTM:

TEST ON UTM

Table 1. Input & Output Data of Lap Joint

Type of Joint: Lap joint			
Input Data		**Output Data**	
Specimen shape	Flat	Load at Peak	1070 KN
Material Type	Aluminium	Elongation at peak	1420 mm
Sample ID	Al-Mg FSW LAP JOINT	Tensile Strength	22.583 N/mm^2
Specimen Width	5.99 mm	Load at Break	0.500 KN
Gauge Length	50 mm		
Specimen Thickness	7.91 mm		
Pre Load Value	0 KN		
Max. Load	200 KN		
Max. Elongation	200 mm		
Specimen Cross Section Area	47.38 mm^2		

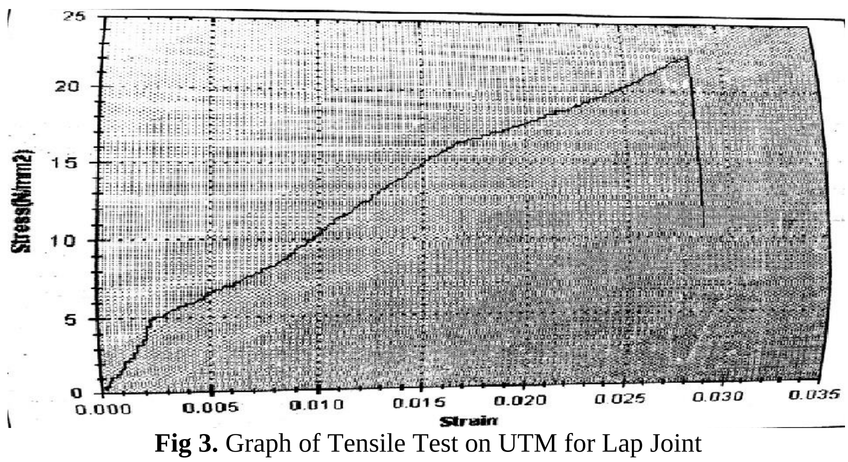

Fig 3. Graph of Tensile Test on UTM for Lap Joint

Table 2. Input & Output Data of Butt Joint

Type of Joint: Butt Joint			
Input Data		**Output Data**	
Specimen shape	Flat	Load at Yield	0.00 KN
Material Type	Aluminium	Elongation at Yield	0.00 mm
Sample ID	Al-Mg FSW LAP JOINT	Yield Stress	0.00 N/mm^2
Specimen Width	12.51 mm	Load at Peak	1.780 KN
Gauge Length	50 mm	Elongation at Peak	0.300 mm
Specimen Thickness	3.96 mm	Tensile Strength	35.931 N/mm^2
Pre Load Value	0 KN	Load at Break	1.080 KN
Max. Load	200 KN	% Elongation	1.46 %
Max. Elongation	200 mm		
Specimen Cross Section Area	49.54 mm^2		
Final Gauge Length	50.73 mm		

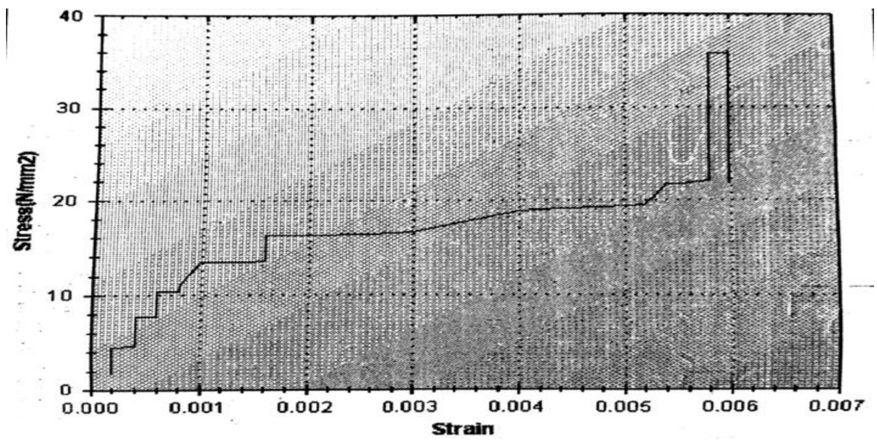

Fig 4. Graph of Tensile Test on UTM for Butt Joint

Defect-free weld between AZ31 Mg and 5083 Al alloy was obtained using friction stir welding with a rotation speed of 560 rpm and travel speed of 25 mm/min. Grain refinement occurred in the stir zone due to dynamic recrystallization. Tensile strength of the welded specimen was about 76% of that of AZ31 Mg alloy and 60% of that of 5083 Al alloy. The mechanical properties of base metals AA5083 (Aluminium alloy) and AZ31B (Magnesium alloy) are modified with friction stir processing by using H13 tool steel as mechtrode. The dissimilar FSW joint between AA5083 aluminium alloy and AZ31B magnesium alloy was able to join and the joint efficiency was achieved to 61%. In support to the results obtained practically the results were compared with the simulation software as mentioned. The component is designed using design software and then imported into the simulative software for further analysis.

The component model is designed for both LAP and BUTT joint using CATIA software by allocating specific material type, properties and then model is imported into the ANSYS software for further static analysis of LAP and BUTT joints. The model is imported and triangular meshing with 5mm grid size is preferred. Both ends of the component is fixed and the load of $2*10^5$ N is applied on the component. After applying the load the deformation is observed.

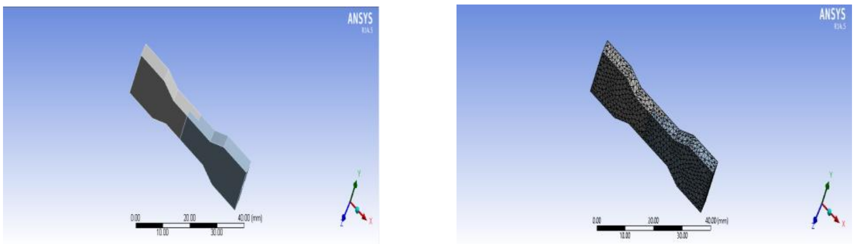

Fig 5. Geometrical model and Meshed model of the LAP Joint

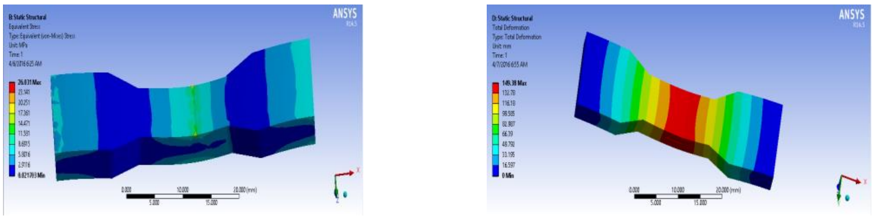

Fig 6. Equivalent stress distributed and Deformed model of LAP Joint

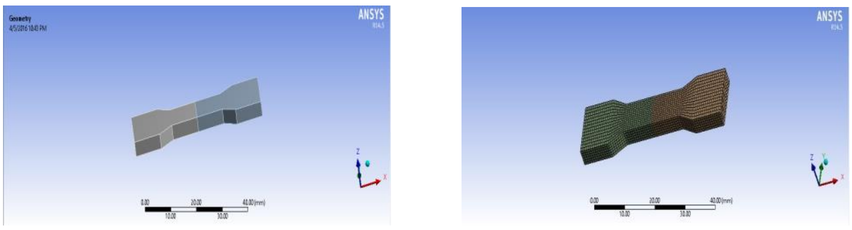

Fig 7. Geometrical model and Meshed model of the BUTT Joint

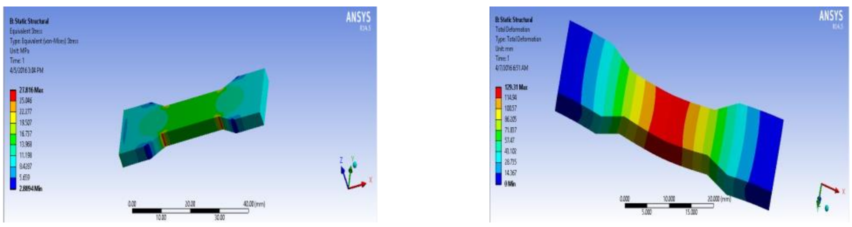

Fig 8. Equivalent stress distributed and Deformed model of BUTT Joint

3 Results

The results of the lap and butt joints of Aluminium and Magnesium components obtained by static analysis using FEA software are shown in the below table:

S.no	Welded joint type	Load (N)	Stress(MPa)	Deformation(mm)
1	Lap joint	200000	26.031	149.29
2	Butt joint	200000	27.816	129.31

The results of the lap and butt joints of Aluminium and Magnesium components obtained by static analysis carried out on Universal Testing Machine are shown in the below table:

S.no	Welded joint type	Load(N)	Stress(MPa)	Deformation(mm)
1	Lap joint	200000	22.583	200
2	Butt joint	200000	35.931	200

4 Conclusions

Friction stir welding is ecologically desirable, closer to the clean machining methods and it will become scope for welding in the future. The Lap joint tensile values are less when compare to butt joint values but still the joint could be attained successfully on conventional milling machine. The theoretical values of lap and butt joints is approximate to that of the practically obtained. Designed and analyzed welded joints are done by using simulation software are appreciable and values obtained are closure to that of lap and butt joints in practical analysis.

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