WELDING AND ANALYSIS ALUMINIUM 6061 ALLOY AND ALUMINIUM 6063 ALLOY IN FRICTION WELDING

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***Abstract* – By the developing technology of today, the necessity of using different materials by joining came out. The most suitable method in joining two different alloyed steel is to weld. The fact that the properties of welding zone are naturally different from the properties of steels in different alloyed at post welding process has come up and these differences occur some important problems. Among many kinds of welding methods, using the melting welding methods has also increased the number of these problems. However, in the connecting zone, many different zones come out by depending on composition and properties of the connecting materials**.

Keywords – Friction welding, Aluminium alloy, Tensile strength.

I. INTRODUCTION

Friction welding techniques are generally melt-free, which avoids grain growth in engineered materials, such as high-strength heat-treated steels. Another advantage is that the motion tends to "clean" the surface between the materials being welded, which means they can be joined with less preparation. During the welding process, depending on the method being used, small pieces of the plastic or metal will be forced out of the working mass (flash). It is believed that the flash carries away debris and dirt.

Another advantage of friction welding is that it allows dissimilar materials to be joined. This is particularly useful in aerospace, where it is used to join lightweight aluminum stock to high-strength steels. Normally the wide difference in melting points of the two materials would make it impossible to weld using traditional techniques, and would require some sort of mechanical connection. Friction welding provides a"full strength" bond with no additional weight. Other common uses for these sorts of bi-metal joins is in the nuclear industry, where copper- steel joints are common in the reactor cooling systems; and in the transport of cryogenic fluids, where friction welding has been used to join aluminum alloys to stainless steels and high-nickel-alloy materials for cryogenic-fluid piping and containment vessels.

II.WELDING

The process of joining similar metals by the application of heat is called “welding”. Welding can be obtained with or without the application of pressure and with or without the addition of filler metal, which is known as electrode. Nowadays welding finds widespread of applications in almost all branches of engineering industry. Welding is extensively employed in the fabrication and erection of steel structure in industry and construction. It is also used in various industries like aircraft frameworks, railway wagons, automobile bodies, ship building, etc.

2.1 Types of welding

Major two types of welding process according to the source of energy employed for heating the metals and the state of metal at the place being welded are:

- Fusion welding
- Plastic welding or solid state welding

Fusion welding:

- In fusion welding, the metal joined at where heat is to transformed in a molten state and then it is allowed to solidify, pressure is not applied during the welding process.And hence it is called as non-pressure welding.

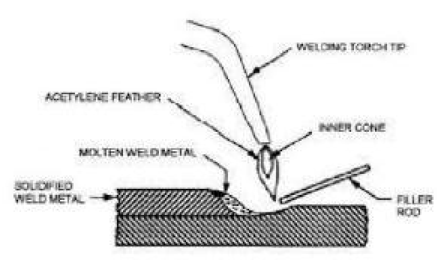

Fig.1 Fusion welding
Eg. Gas welding, Arc welding, Thermit welding

Plastic welding

In Plastic welding, the metal parts are heated to a plastic state and are pressed together to make the joint. Hence it is also known as pressure welding or solid state welding.

E.g. Friction stir welding, Friction welding, Forge welding, Electrical resistance welding.

Fig.2 plastic welding

III.FRICTION WELDING

3.1 INTRODUCTION

Friction welding is a solid state process, where no electric or other power sources are used, mechanical energy produced by friction in the interface of parts to be welded are utilized. Using heat efficiently in the welding region is only possible by efficiently distributing heat on surfaces, to which welding will be applied.

- In Friction welding (FRW) process heat is generated through mechanical friction between a moving work piece and a stationary component, with the addition of a lateral force called "upset" to plastically displace and fuse the materials.

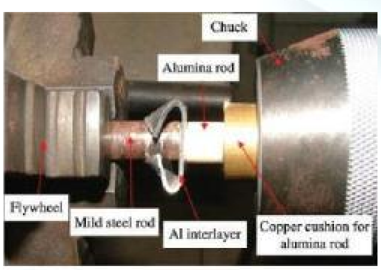

Figure 1. Experimental setup for the FW process.

Fig 3 friction welding

3.2 Machine Set Up

- Initially, parts are loaded into the friction welding equipment. Experienced operators setup the machine for each job to control the 3-step process with a series of parameters unique to each job such as rotational Speed, friction pressure, and upset pressure and burn-off Length.

- After the three parameters are established, they're recorded and stored for use throughout the entire project. Using this quality approach ensures repeatable consistency for each additional weld produced on the machine. The results are represented visually on the Playback Graph shown below the three steps.

Stage 1

- One component is positioned in a stationary clamp. The second part is positioned in the rotating spindle, which is then brought up to a pre-defined rotational speed (blue line on graph). At the right moment, pre-defined axial force (red line on graph) is applied.

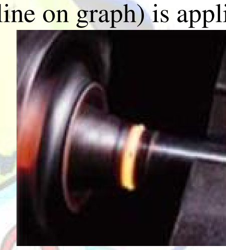

Fig 4 Stage 1 of welding

Stage 2

These conditions are maintained for a predetermined time. A second step of pressure is applied until the desired temperatures and material conditions exist. It's during this stage that the two materials are plasticized (become malleable). The green line signifies measurement of "length loss" and triggers the stopping point when the part reaches planned Overall Length.

Fig 5 stage 2 of welding

Stage 3

Rotational speed is stopped. Then increased axial force (third step in the red line at 9.5 seconds) is applied to create "forge pressure" for another predetermined time – completing the weld. This provides molecular bonding and grain refinement through the weld zone.

Fig 6 stage 3 of welding

TENSILE TEST

Tensile testing, also known as tension testing is a fundamental materials science test in which a sample is subjected to a controlled tension until failure. The results from the test are commonly used to select a material for an application, for quality control, and to predict how a material will react under other types of forces. Properties that are directly measured via a tensile test are ultimate tensile strength, maximum elongation and reduction in area. From these measurements the following properties can also be determined: Young's modulus, Poisson's ratio, yield strength, and strain-hardening characteristics. Uniaxial tensile testing is the most commonly used for obtaining the mechanical characteristics of isotropic materials. For anisotropic materials, such as composite materials and textiles, biaxial tensile testing is required. Tensile testing machine is shown in fig.

Fig.7 Tensile testing machine

IV BASE MATERIALS

4.1 ALUMINIUM

4.1.1 Light Weight

Aluminium is one of the lightest available commercial metals with a density approximately one third that of steel or copper. Its high strength to weight ratio makes it particularly important to transportation industries allowing increased payloads and fuel savings. Catamaran ferries, petroleum tankers and aircraft are good examples of aluminium use in transport.

4.1.2 Corrosion Resistance

Aluminium has excellent resistance to corrosion due to the thin layer of aluminium oxide that forms on the surface of aluminium when it is exposed to air. In many applications, aluminium can be left in the mill finished condition. Should additional protection or decorative finishes be required and then aluminium can be either anodized or painted.

4.1.3 Strength

Although tensile strength of pure aluminium is not high, mechanical properties can be markedly increased by the addition of alloying elements and tempering. You can choose the alloy with the most suitable characteristics for your application. Typical alloying elements are manganese, silicon, copper and magnesium.

4.1.4 Easy To Work

Aluminium can be easily fabricated into various forms such as foil, sheets, geometric shapes, rod, tube and wire. It also displays excellent machinability and plasticity ideal for bending, cutting, and spinning, roll forming, hammering, forging and drawing. Aluminium can be turned, milled or bored readily, using the correct tool age. In fact, most aluminium alloys can be machined speedily and easily. An important factor contributing to the low cost of finished aluminium parts.

4.1.5 Heat Conductivity

Aluminium is about three times as thermally-conductive as steel. This characteristic is important in heat-exchange applications. Aluminium is used extensively in cooking utensils, air conditioning, industrial heat exchangers and automotive parts.

4.2 Physical Properties

Density	2700 kg/m3
Melting Point	580°C
Modulus of Elasticity	70-80 GPa
Electrical Resistivity	0.399x10-6 Ω.m
Thermal Conductivity	167 W/m.K
Thermal Expansion	25x10-6 /K

Table 1 physical Properties of Aluminium Alloy 6061

4.3 CHEMICAL COMPOSITION OF Al 6061 ALLOY

Element	Al 6061 (%)
Mg	1.2
Si	0.8
Mn	0.15
Cu	0.4
Cr	0.35
Zn	0.25
Ti	0.15
C	----
P	
S	----
Al	----
Fe	Balance
	0.7

Table 2 CHEMICAL COMPOSITION OF Al 6061 ALLOY

4.4 Physical Properties of Aluminium Alloy 6063

Density	2700 kg/m3
Melting Point	650°C
Modulus of Elasticity	70 GPa
Electrical Resistivity	0.332x10-6 Ω.m
Thermal Conductivity	200 W/m.K
Thermal Expansion	25x10-6 /K

Table 3 physical Properties of Aluminium Alloy 6063

4.5 CHEMICAL COMPOSITION OF ALUMINIUM 6063 ALL0Y

Element	**MS (%)**
Mg	0.9
Si	0.6
Mn	0.1
Cu	0.1
Cr	0.1
Zn	0.1
Ti	0.1
C	0.15
P	
S	0.21
Al	0.06
Fe	Balance
	0.35

Table 4 Chemical Composition of Aluminium alloy 6063

V EXPERIMENTAL ACTIVITIES AND TEST RESULTS

5.1 OPTIMIZED PARAMETERS USED FOR THE FRICTION WELDING PROCESS

S.NO	FRICTION LOAD	SPEED	TIME	FORGING LOAD
1	58	1500	4	58
2	40	1400	4	40

3	40	1000	3	40
4	30	1000	3	30
5	35.5	1000	3	35.5
6	35.8	900	3	35.8
7	30.8	900	3	30.8
8	30	1000	2	30
9	30.8	900	4	30.8

Table 5 parameters for FRW

5.2 TENSILE TEST RESULTS

Sample no.	FP (tonnes)	UP (tonnes)	SPEED (rpm)	TENSILE STRENGTH (MPa)
1	0.040	0.040	1000	
2	0.030	0.030	1000	
3	0.0355	0.0355	1000	
4	0.0358	0.0358	900	

Table 6 Tensile Test Results

VI. CONCLUSION

The purpose of this work was to join and assess the development of solid state joints of dissimilar material Al 6061 aluminum alloy and Al 6063 aluminum alloy, via continuous drive friction welding process, which combines the heat generated from friction between two surfaces and plastic deformation. Tests were conducted with different welding process parameters. The results were analyzed by means of tensile test, Vickers micro hardness test, analysis in order to determine the phases that occurred during welding.

The strength of the joints varied with increasing friction pressure, upset pressure and upset time constant. The joint strength increased, and then decreased after reaching a maximum value, with increasing friction pressure and friction time.

The process of friction welding between the aluminum alloy and the aluminum alloy is proposed to evolve as follows: welding progresses from the outer to the inner region; an unbounded region is retained at the center of the weld interface with shorter friction time; longer friction time causes the formation of an intermetallic reaction layer at the weld interface and the reaction layer grows as the friction time increases. Some of the welds had poor strength due to the accumulation of alloying elements at the joint interface. The joint was sound when there was no unbounded region and a thin reaction layer formed along the entire weld interface.

From conducting various results, we have found out sample 3 is best suited for high strength of 104Mpa. From hardness test results, we have found out sample 1 is having good hardness.

Thus based on application we can manufacture work piece by this conclusion.

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