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FRICTION WELDING PROCESS OF ALUMINIUM 5083 ALLOY WITH MILD STEEL

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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. However, in the connecting zone, many different zones come out by depending on composition and properties of the connecting materials.**

Deposits remain of the melting welding methods, welding faults of porosity and inside tightens of cooling are the important disadvantages of these methods and they decreases the strength of welding. By using friction welding we can develop a solid state joints of dissimilar material of aluminum alloy and mild steel. It is a continuous drive friction welding process, which combines the heat generated from friction between two surfaces which results in plastic deformation of the parent metals. This analysis helps to reduce the weight of automobile parts in the manufacturing of turbine blades and vehicle axles, etc.

Index Terms—**Friction pressure , upset pressure**

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.

WELDING

The process of joining similar metals by the application of heat is called “welding”.

TYPES OF WELDING:

Fusion welding & Plastic 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. Eg. Gas welding.

DEFECTS IN FUSION WELDING:

- Incomplete fusion
- Cracks
- Porosity
- Under cut

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

Friction welding is a solid state process, where no electric or other power sources are used, mechanical energy

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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.

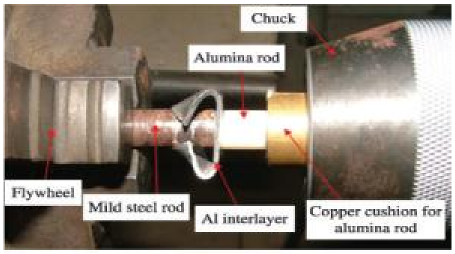


Figure 1. Experimental setup for the FW process.

- 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.

REASONS FOR FRW:

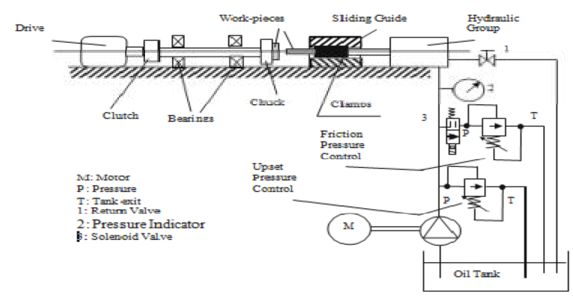
The heating phase continues until plastic forming temperature is achieved. The temperature in the welding region for steels is between 900 and 13000C.

PARAMETERS OF FRICTION WELDING

Apart from traditional welding methods, several welding parameters can be controlled in friction welding. These parameters include diameter of experimental rod, rpm of the part, rpm of parts in to lathe, friction contact time, forging delay time, forging time, time of increased friction pressure, friction pressure.. The rpm of rotating parts, friction time, friction pressure, forging pressure and time are the parameters needed to be taken into account while optimizing the welding process. A successful welding process can occur if parameters are optimized. The lower rpm of rotating parts causes enormous moments and no uniform heating results in. On the other hand, lower rpm values minimize formation of inter metallic compounds. To prevent overheating in the welding region, friction pressure and friction time have to be carefully controlled. Pressure values applied in welding is very significant because it controls temperature gradient and affects rotational torque as well as power. Friction and forging pressure are directly related to geometry and material properties of parts to be welded and have a wide range. Over applied pressure values increase power needs accordingly. Due to increased energy input, higher pressures decrease the width of ITAB, accelerate metal displacement ratio and reduces welding time resulting in heat band on the boundary. The variable of pressure can be controlled by the temperature in welding region and decrease in axial length. Optimum pressure must be applied to materials in order to get uniform deformations throughout. Friction pressure has to be high enough to allow the removal of oxides, to get uniform heating throughout and to interrupt the affinity between surfaces and the air.

PARTS OF THE FRICTION WELDING MACHINE:VARIOUS PARTS:

1. Drive
2. Clutch
3. Chuck
4. Clamp
5. Bearings
6. Hydraulic unit
7. Return valve



8. Solenoid valve

APPLICATIONS OF FRICTION WELDING:

- Machine production and spare part industry: cogwheels, piston rods, hydraulic cylinders, radial pomp pistons, shaft with worm screw, crankshafts, drill bits, valves.
- Automotive industry : valves, clack valve, drive shafts, gear levers, axle fasteners, break spindles, transmission mechanisms, preheat rooms, pipe spindles, banjo axles.

ADVANTAGES AND DISADVANTAGES OF FRICTION WELDING:

Friction welding has better technical and economical properties than conventional welding methods. Friction welding is generally compared to electrical resistance welding. However it can also be compared to other welding methods such as electron beam welding and electrical arc welding.

- One of the main advantages of friction welding is lower energy requirement.
- The process has unusual high yield and lower energy requirement and power supply. Moreover, power

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requirement of friction welding is about one tenth of electrical resistance welding.

BASE MATERIALS

ALUMINIUM:

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.

ALUMINIUM ALLOY DESIGNATIONS:

Density	2650 kg/m^3
Melting Point	570°C
Modulus of Elasticity	72 GPa
Electrical Resistivity	0.058x10-6 Ω.m
Thermal Conductivity	121 W/m.K
Thermal Expansion	25x10-6 /K

CHEMICAL COMPOSITION OF AL 5083 ALLOY:

Element	Al 5083 (%)
Mg	4.60
Si	0.08
Mn	0.62
Cu	0.02
Cr	0.06
Zn	0.01
Ti	0.02
C	----
P	----
S	----
Al	Balance
Fe	0.21

MILD STEEL

Strength, hardness, toughness, elasticity, plasticity, brittleness, and ductility and malleability are mechanical properties used as measurements of how metals behave under a load. These properties are described in terms of the types of force or stress that the metal must withstand and how these are resisted.

CHEMICAL COMPOSITION OF MILD STEEL:

Element	MS (%)
Mg	----
Si	0.02
Mn	0.42
Cu	----
Cr	----
Zn	----
Ti	----
C	0.15
P	0.21
S	0.06
Al	----
Fe	Balance

CALCULATION

SPECIMEN DIMENSION:

Length of the rod = 75 mm
Diameter of the rod = 20mm
Burn off length = 2mm (constant)
Spindle speed = 1500 rpm
Friction time = 3sec
Upset time = 6 sec

CALCULATION OF CROSS SECTION AREA OF THE ROD:

Diameter of the rod = 20 mm
Length =75mm
Cross section of the Area of the specimen,

$A=\frac{\pi}{4}d^2$

$A=\frac{\pi}{4}(0.020)^2$

Area, A=3.141×10-4 m^2

CONVERSION OF FRICTION PRESSURE IN MPA INTO TONNES:

1Mpa=101.9716 ton/m^2

Hence,

1) 65 Mpa=65×106 N/m^2

$=\frac{65\times10^6}{9.81}\times\frac{\pi}{4}\times\frac{(0.020)^2}{1000}$

= 2.081 tonnes

65 Mpa ~ 2 tonnes

CONVERSION OF UPSET PRESSURE IN MPA INTO TONNES:

1) 141 Mpa=141×106 N/m^2

$=\frac{141\times10^6}{9.81}\times\frac{\pi}{4}\times\frac{(0.020)^2}{1000}$

= 4.515 tonnes

141Mpa ~ 4.5tonnes

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EXPERIMENTAL SETUP

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.

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.

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

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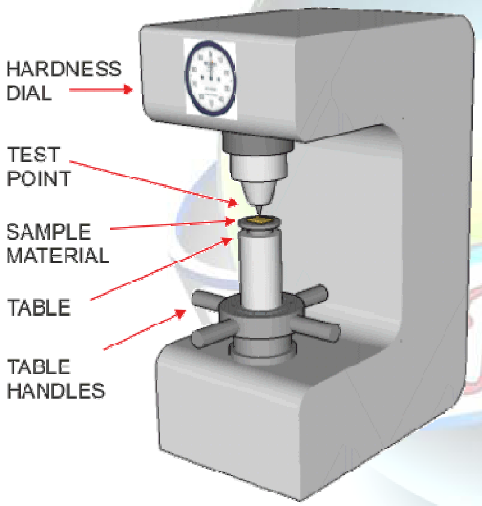
grain refinement through the weld zone.

TESTING METHODS:

1.HARDNESS TEST



Hardness testing is a general method for measuring the bulk hardness of metallic and polymer materials. Although hardness testing does not give a direct measurement of any performance properties, hardness correlates with strength, wear resistance, and other properties. Hardness testing is widely used for material evaluation due to its simplicity and low cost relative to direct measurement of many properties.

2.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. From these measurements the following properties can also be determined: Young's modulus, Poisson's ratio, yield strength, and strain-hardening characteristics.

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WELDING PARAMETERS:

The various parameters involving in the friction welding process are as follows:

1. Friction pressure (tonnes)
2. Upset pressure(tonnes)
3. Shrinkage limit(mm)
4. Spindle Speed(rpm)
5. Friction time(sec)
6. Upset time(sec)
7. Burn-off length(mm)
8. Slide stop position(mm)
9. Cycle stop time(sec)

EXPERIMENTAL ACTIVITIES AND TEST RESULTS:

1.OPTIMIZED PARAMETERS USED FOR THE FRICTION WELDING PROCE SS:

S.NO	FRICTION PRESSURE (in tonnes)	UPSET PRESSURE (in tonnes)	SPEED (rpm)
1	2	4.5	1500
2	3.5	5.5	1500
3	5	6.5	1500

2. TENSILE TEST RESULTS:

S.NO	FRICTION PRESSURE (tonnes)	UPSET PRESSURE (tonnes)	SPEED (rpm)	TENSILE STRENGTH (MPa)
1	2	4.5	1500	50.38
2	3.5	5.5	1500	94.27
3	5	6.5	1500	104.05

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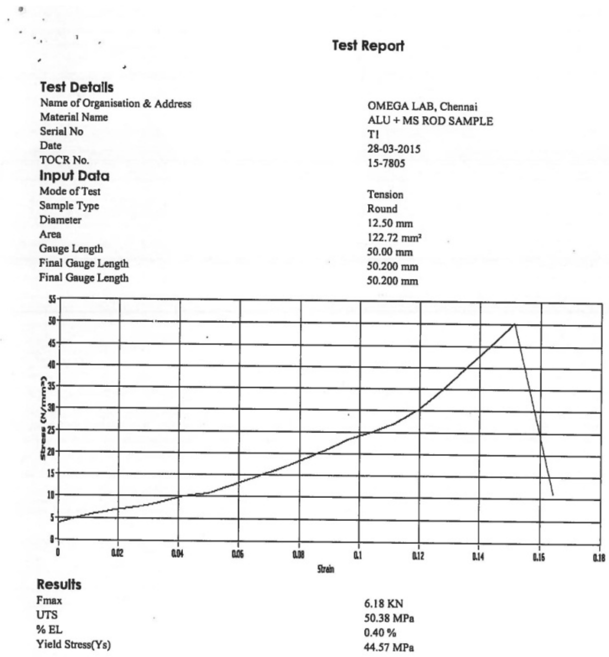

Test Report

Test Details

Name of Organisation & Address	OMEGA LAB, Chennai
Material Name	ALU + MS ROD SAMPLE
Serial No	T1
Date	28-03-2015
TOCR No.	15-7805

Input Data

Mode of Test	Tension
Sample Type	Round
Diameter	12.50 mm
Area	122.72 mm²
Gauge Length	50.00 mm
Final Gauge Length	50.200 mm
Final Gauge Length	50.200 mm

Results

Fmax	6.18 KN
UTS	50.38 MPa
% EL	0.40 %
Yield Stress(Ys)	44.57 MPa

MICROSTRUCTURE OF THE WELDED METALS:

SAMPLE NO.1

Friction pressure = 2 tonnes
Upset pressure = 4.5 tonnes
Spindle speed = 1500 rpm

CONCLUSION:

The purpose of this work was to join and assess the development of solid state joints of dissimilar material Al 5083 aluminum alloy and Mild steel, via continuous drive friction welding process, which combines the heat generated from friction between two surfaces and plastic deformation.

REFERENCES:

[1]E. D. Nicholas, Friction welding-an introduction to the process, The Welding Institute Cambridge, PP 2-8.
[2] Christo Ananth, S.Esakki Rajavel, S.Allwin Devaraj, M.Suresh Chinnathampy. "RF and Microwave Engineering (Microwave Engineering)." (2014): 300.
[3] Exploiting friction welding in production, Information package series, The Welding Institute Cambridge, PP 2 - 56.
[4]ANSI/AWS C6.1-89 – Recommended Practices for Friction Welding.
[5] Kuka code of practices DVS 2909, Germany Association for Welding Technology, Friction Welding of metals: Structure and Manufacture, Feb.1981, PP 1-8.
[6] AWS C6.2/C6.2M: 2006 – Specification for Friction Welding of Metals.