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AN INVESTIGATION ON ADVANCED WELDING TECHNIQUES

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Abstract

This paper deals with advanced welding techniques with use of friction stir welding. This type of welding carried out by aluminium 6063 alloy practically. When compared to conventional welding techniques it is not possible to weld, such type of aluminium alloy, because of some limitations. Friction stir welding is one such non-melting joining technology that has produced structural joints superior to conventional arc welds in aluminium.

Friction stir welding can be conducted on a milling machine. While doing the experiment with change in variation of rotational speed and feed rate, with that experiment we chose five trials. In between five trials, the trials from one to four gives as different types of welds obtained. At the end of fifth trial, successful weld was obtained with very good surface finish on both ends and better tensile strength at types of welds obtained. At the end of fifth trial , successful weld was obtained with very good surface finish on both ends and better tensile strength at 1400rpm and 22.4 mm/rev. Tests were also performed to determine the susceptibility of FSW aluminium 6063 alloy to corrosion. The various test performed on the welded specimen are as follows tensile test and microstructure study.

During tensile test, the maximum tensile strength obtained from two specimens was approximately 75% of the parent metal. Whereas the microstructure analysis is carried out to decrease the flow of material and change in the microstructure and grain size of measurement. By using this factor we present the paper that FRICTION STIR WELDING as a advanced welding techniques.

***Keywords**:* Friction Stir Welding,aluminium 6063 alloy,Trails,Surface Finish

1. FRICTION STIR WELDING

Friction stir welding represents one of the most significant developments in joining technology in the last half century. Friction stir welding is one such non-melting joining technology that has produced structural joints superior to conventional arc welds in aluminium. Friction stir welding produces higher strength, increased fatigue life, lower distortion, less residual stress, less sensitivity to corrosion and essentially defect free joints compared to arc welding.

1.1 Basic Principle

Friction stir welding (FSW) is a solid-state thermo-mechanical joining process, where the actual mechanism of weld formation is most nearly described as a combination of extrusion combined with forging.

These welds require low energy input and are without the use of filler materials and distortion. Initially developed for non-ferrous materials such as aluminium, by using suitable tool materials the use of the process has been extended to harder and higher melting point materials such as steels titanium alloys and copper.

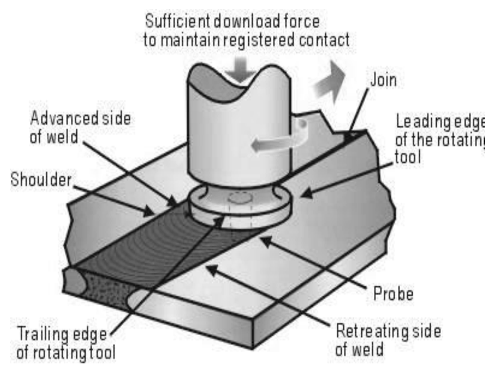

Figure: 1 Friction Stir Welding

In friction stir welding (FSW) a cylindrical, shouldered tool with a profiled probe is rotated and slowly plunged into the joint line between two pieces of sheet or plate material, which are butted together. The parts have to be clamped onto a backing bar in a manner that prevents the abutting joint faces from being forced apart. Frictional heat is generated between the wear resistant welding tool and the material of the work pieces. This heat causes the latter to soften without reaching the melting point and allows traversing of the tool along the weld line.

Aluminium alloy 6063: Aluminum alloy 6063 is a medium strength alloy commonly referred to as an architectural alloy. It has a good surface finish; high corrosion resistance is readily suited to welding and can be easily anodized.

CHEMICAL COMPOSITION:

Element	6063 % Present
Si	0.2 to 0.6
Fe	0.35
Cu	0.1
Mn	0.1
Mg	0.45 to 0.9
Zn	0.1
Ti	0.1
Cr	0.1
Al	Balance

Table: 1 Chemical Composition

2. TRAILS PERFORMED

TRIAL: 1 In the first trail aluminium 7075-T6 sheet of 3mm was used. The tool used had short shoulder length and the pin length was 3 mm. The trial was conducted at a speed of 1400 RPM and a feed of 45 mm/min.

- Cavity formation on the weld surface due to low friction generated by the tool on aluminium
- Projection of material on other side of the weld was found

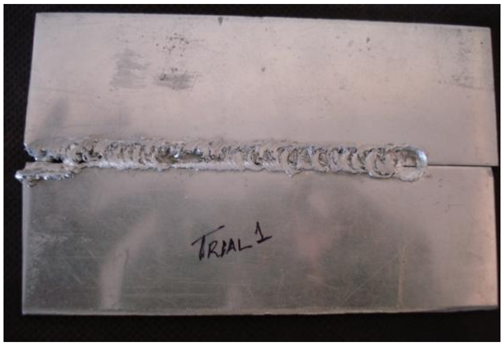

Figure: 2 Trail 1

TRIAL: 2

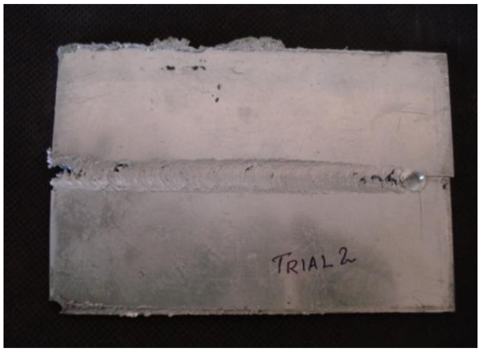

Figure: 3 Trail 2

It was also performed on the same aluminium sheet but certain changes were made. The tool length was increased so as to obtain a better shoulder contact on aluminium and there by increasing the friction produced.

- A better weld joint was obtained than the earlier one
- The surface finish was poor due to slight looseness in the tool

TRIAL: 3

Again the same grade of aluminium sheet was tried. In order to avoid the slipping of the tool, a hole was drilled on the tool for M6 Allen Grub Screw. This would give a strong hold for the tool and reduce the vibration which resulted in a poor surface on the earlier trial.

The inferences made from the resultant weld are

- Obtained a better weld surface
- A Proper joint was obtained for about 95% of the specimen thickness
- But the surface on the other side of the weld was not good

Figure: 4 Trail 3

TRIAL: 4

Figure: 5 Trail 4

The gap that was there in the earlier trial was removed. The aluminium sheet now will rest completely on the support block. When the trial was performed the following inferences were made

- Axial load given was higher
- Thickness of the weldment got reduced
- Due to excess load material overflowed on the sides of the weldment
- But a good weld joint was obtained

TRIAL: 5

Aluminium 6063 sheet was used with the same tool and the same fixturing was used. The trial was run at a speed of 1400 RPM and at a feed rate of 22.4 mm/min and 31 mm/min. This trial was a successful one and a good surface was obtained on both the sides of the weld. 100% joint was obtained. The joint was not strong enough that of the earlier weld.

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Figure: 6 Trail 5

3. EXPERIMENTATION

Friction stir welding can be conducted on a milling machine. Tests were also performed to determine the susceptibility of friction stir welded aluminium 6063 alloy to corrosion. The various tests performed on the welded specimen are as follows.

- Tensile test
- Microstructure study

3.1 Tensile Test

The tensile test specimen has a dumb bell shape which has hole on its both ends for holding in tensile testing machine. The necking phenomenon has been used to determine the tensile strength of the specimen. The specimen for tensile test was produced using CNC wire EDM cutting process

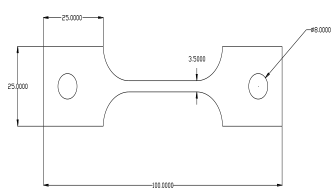


Figure: 7 Two dimensional representation

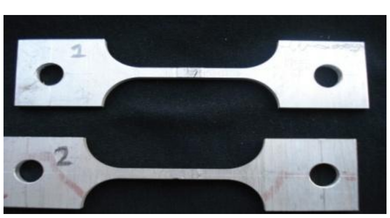


Figure: 8 Tensile Test Specimen

Calculation of % elongation

Original length = 50mm

Final length = 52mm

% Elongation = $(L_f - L_0 / L_o) \times 100$

= (52-50 / 50) x 100

% Elongation = 4

The maximum tensile strength obtained from the two specimens was approximately 75% of the parent material.

Tensile test results

Specimen	Operating Conditions		Tensile strength (N/mm^2)
	Speed(rpm)	Feed (mm / min)	
Specimen 1	1400	31	75
Specimen 2	1400	22.4	96

3.2 Microstructural Analysis

Different zones in a weld specimen

A. Unaffected material

B. Heat affected zone (HAZ)

C. Thermo-mechanically affected zone (TMAZ)

D. Weld nugget (Part of thermo-mechanically affected zone)

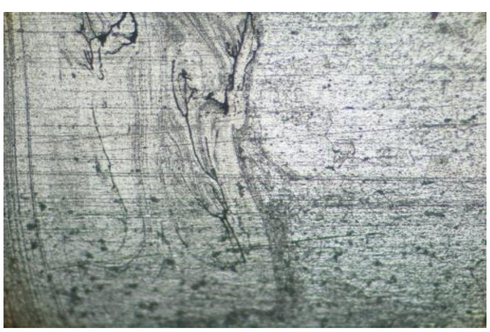
Unaffected Material Or Parent Metal: This is material remote from the weld, which has not been deformed,it may have experienced a thermal cycle from the weld is not affected by the heat in terms of microstructure or mechanical properties.

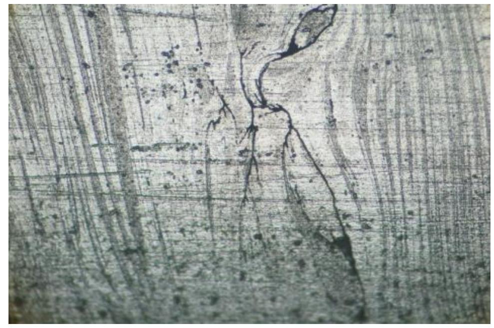
Heat Affected Zone (HAZ): The region of the parent metal which has undergone a metallurzied change as a research of the thermal cycle is called heat affected zone or thermally affected zone.

Thermo-Mechanically Affected Zone (TMAZ): In this region, the material has been plastically deformed by the friction stir welding tool, and the heat from the process will also have exerted some influence on the material. In the case of aluminium, it is possible to get significant plastic strain without recrystallisation in this region.

Weld Nugget: The recrystallised area in the TMAZ in aluminium alloys has traditionally been called the nugget. The microstructure analysis is carried out to determine the flow of the material and change in the microstructure and grain size of the material. The second microstructure photo shows the heat affected zone with the parent material. This photo helps in the comparison of the two. Cracks are found in the heat affected zone.
The third picture shows the structure of weld nugget .Formation of small cracks due to improper fusion can be seen. The metal flow is seen clearly. Incomplete metal flow resulting in incomplete convergence and void formation. The fourth photo shows the flow pattern of metal

4. MICROSTRUCTURE OF SPECIMEN





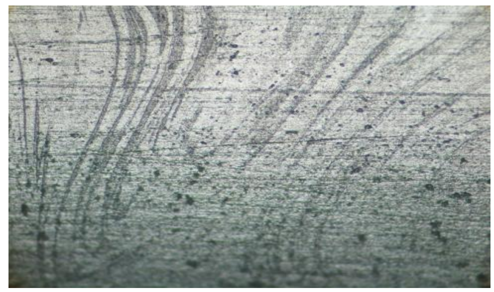


Figure: 9 Microsturcture of Specimen

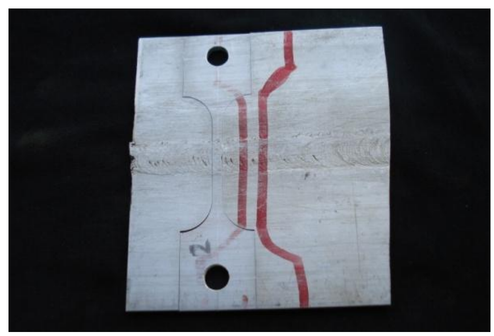


Figure: 10 Weld Specimen – I

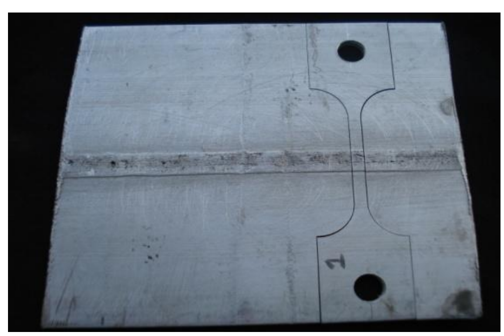


Figure: 11 Weld Specimen – II

5. RESULTS AND DISCUSSION

Experiments were conducted on aluminium sheets 6063 with different parameters and finally a successful butt weld joint was obtained between the two plates. The various trials that were performed are as follows.

RESULTS:

Trial no.	Rotational speed (in RPM)	Feed (in mm / min)	Weld obtained
1.	900	45	Literally a weld was obtained with voids on the top surface of the weld with a formation of bead on the bottom surface.
2.	1400 (with a pin length of 3 mm)	31	Better weld was obtained with a penetration the pin on the bottom side of the specimen.
3.	1400 (with a pin length of 2.7 mm)	31	Better weld was obtained with a worm hole resulting in a lesser tensile strength with a good surface finish on both surfaces.
4.	1400 (with a pin length of 2.7 mm)	22.4	Successful weld was obtained with very good surface finish on both sides and better tensile strength.

Table: 2 Results

Successful weld was obtained with a rotational speed of 1400 RPM and a feed rate of 22.4 mm /min was used. Trials were also made with two dissimilar metals such as copper and aluminium and the other pair of aluminium was not very successful to that of aluminium.

The results showed that weldment in the specimen 1 had a little less tensile strength than specimen 2 due to the presence of small voids throughout the weld area.

5.1 Friction Stir Welding - Process Advantages And Limitations

The process advantages result from the fact that the FSW process (as all friction welding of metals) takes place in the solid phase below the melting point of the materials to be joined. The benefits therefore include the ability to join materials which are difficult to fusion weld, for example 2000 and 7000 aluminium alloys. Friction stir welding can use purpose-designed equipment or modified existing machine tool technology. The process is also suitable for automation and adaptable for robot use. Other advantages are as follows:

- Low distortion, even in long welds
- Excellent mechanical properties as proven by fatigue, tensile and bend tests
- No fume
- No porosity
- No spatter
- No gas shielding for welding aluminum
- No grinding, brushing or pickling required in mass production .
- Can weld aluminum and copper of >50mm thickness in one pass.

5.2 The Limitations Of Friction Stir Welding

The limitations of the FSW process are being reduced by intensive research and development.

- Work pieces must be rigidly clamped

- Keyhole at the end of each weld
- Cannot make joints which required metal deposition

6. CONCLUSION

Friction stir welding on Al 6063 has been done successfully. Some limitations were encountered in the machine specifications. The available machine was not sufficient for welding copper and other high melting point metals. Various tests were performed to study the physical properties and their results are as follows

- The hardness of the weld region is higher than that of the parent material. This reveals that the welding is proper.
- The maximum tensile strength obtained the two specimens was approximately 75% of the parent material.
- The tensile test also proved a better weld joint.

Thus from the experimental procedure and testing result it can be concluded that friction stir welding can be done using a universal milling machine and a weld of good strength can be obtained.

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