FRICTION STIR WELDING PARAMETER OPTIMIZATION USING OPTIMIZATION PROCESS

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ABSTRACT

The focus of the project work will be concentrated in the mechanical performance and the stir zone microstructure by FSW butt welded part having 150mm × 50mm × 5mm thick sheet 5000 series aluminum alloy 6061 and 150mm × 50mm × 5mm thick The same sheet using tool steel material having taper tool pin profile. And same specimen plates having size (150mm × 50mm × 5mm) welded by Oxyacetylene welding process. All the testing of welded part will be tested by ASTM standard. In this work, (UTM), Inverted Microscope (IM) to get the microstructure properties.

Keyword: -*Friction Stir Welding(FSW), AZ31,AZ91, microstructural analysis*

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1. Friction Stir Welding

Friction stir welding (FSW) is a relatively new solid-state joining process. This joining technique is energy efficient, environment friendly, and versatile. The principal advantages are low distortion, absence of melt related defects and high joint strength. In FSW parameters play an important role like tool design and material, tool rotational speed, welding speed and axial force.

Friction stir welding (FSW) is a solid state joining technique that was invented at The Welding Institute (TWI), United Kingdom in1991 and has found applications in a wide variety of industries, including aerospace, automotive, railway and marine. It is an alternative welding technology process to fusion welding. A defining characteristic of FSW is that the joint is created by a cylindrical rotating tool, mechanically traversed through the materials. Frictional heat is generated between the wear-resistant welding tool shoulder and pin, and the material of the work-pieces. The frictional heat and surrounding temperature causes the stirred materials to best oftened and mixed.

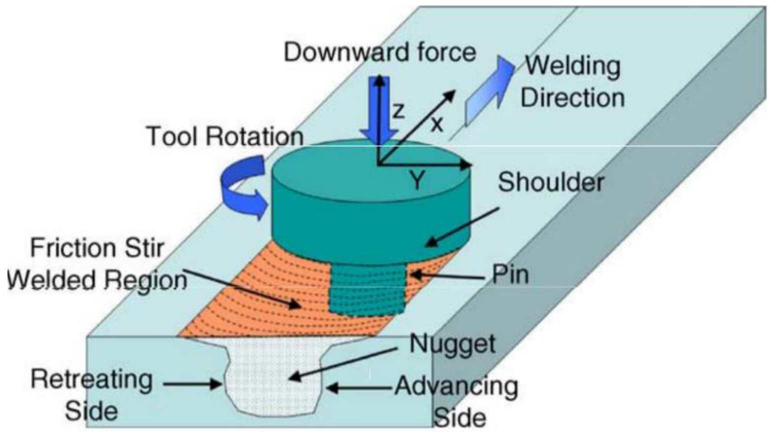

Figure No1. Schematic Diagram of Friction Stir Welding [4]

2. Objective

1. To manufacture of H13taper tool for welding.
2. To do experimental verification of welded joint at different FSW parameters. (Rotational speed, feed rate).
3. To determine the most significant factor affecting strength of joint.
4. To perform micro structural study of welded joint.
5. To develop environmental and human safe welding process.

3. Scope

The focus of the research work will be concentrated in the mechanical performance and the stir zone microstructure by FSW butt welded part having 150mm × 50mm × 5mm thick sheet 5000 series aluminum alloy considered as magnesium alloys (AZ31 & AZ91) and 150mm × 50mm × 5mm thick sheet using tool steel material having taper tool pin profile. All the testing of welded part will be tested by ASTM standard. In this work, Universal Testing Machine (UTM), Inverted Microscope (IM) to get the microstructure properties.

4. Methodology

For the every process there is some planning is required and that planning is executed by some steps so as project work is concerned it has divided into several stages. The basic process flow diagram of work is as below.

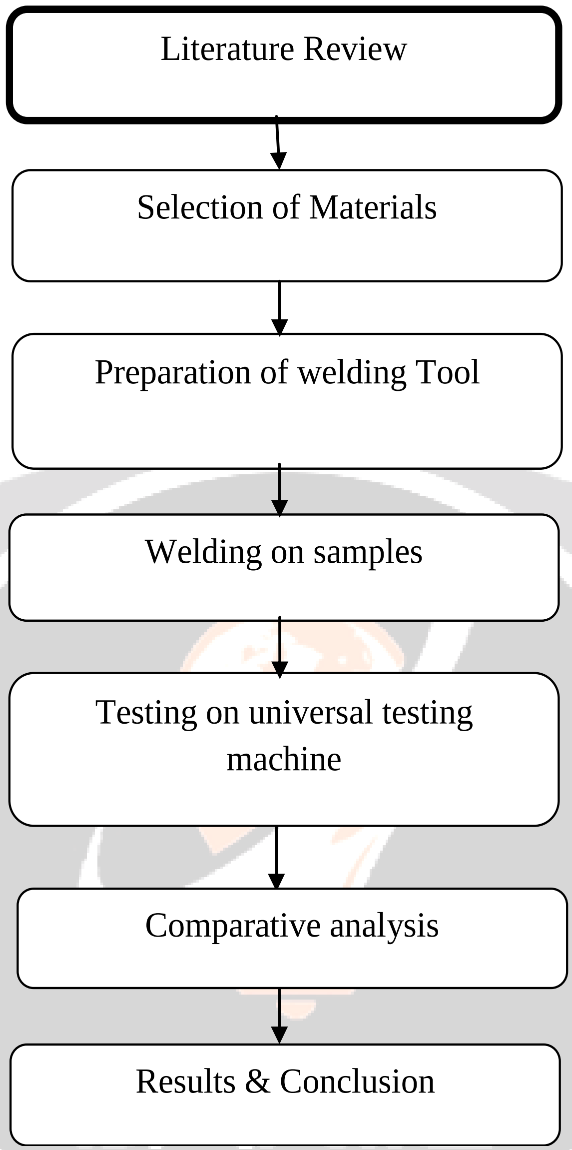

Figure No.2 Flow of process

5. Base Material

In the process of friction stir welding the material selection is important part from the base materials the other parameters are decided like tool material, rotational speed, down force, translational speed FSW can be used for joining many types of materials and also different material combinations. Most of the efforts done in FSW research and development have been performed to optimize the process for joining aluminium and its alloys. A group of TWI Industrial Members demonstrated that the following aluminium alloys could be successfully friction stir welded to produce high integrity welds within defined parametric tolerances: 2000 series aluminium (Al-Cu), 5000 series aluminium (Al-Mg), 6000 series aluminium (Al-Mg-Si), 7000 series aluminium (Al-Zn) and 8000 series aluminium (Al-Li). In the case of different alloys, joining aluminium and steel alloys is of significant importance, and recently Honda Company has successfully performed such welding in a vehicle suspension system for mass production [3].The composition of alloys of magnesium the AZ31 is 2.75% Al, 0.001% Fe, 0.91 % Zn, 0.01 % Mn and magnesium for balance and AZ91 having the composition as 8.67% Al, 0.002% Fe, 0.85% Zn, 0.03% Mn and magnesium for balance and mechanical properties of alloys as AZ31 having tensile strength of 272 N/mm^2 and elongation is 7.2 %, and AZ91 having tensile strength of 240 N/mm^2 and elongation is 16.8%. Alloys of magnesium plates (150mm X 50mm X 5mm) were used for this experiment. The material of the tool is H13 steel is used.

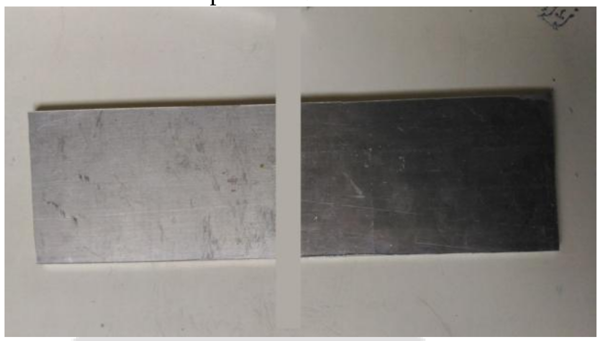

Figure No.3 Actual Base Material Plate

6. SECTION FOR TESTING

Tensile test specimens were prepared according to the guidelines of the American Society for Testing of Materials (ASTM) shown in figure No 4.8. Tensile test was carried out on 400 ton Universal Testing Machine at room temperature. The specimen was loaded as per ASTM so that tensile undergoes deformation. Then specimen finally failed after necking and the load v/s displacement was recorded. The ultimate tensile strength, percentage elongation and joint efficiency were evaluated. Specification of the tensile specimen: Crosssectional area = 5x15=75$mm^2$and Gauge length=90mm.

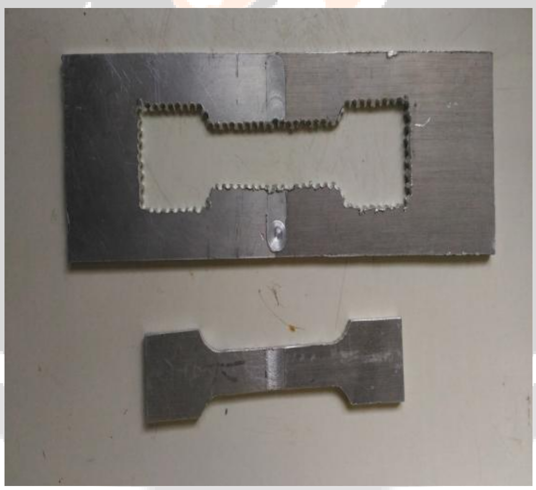

Figure No.4 Dimensions of the Test Specimens as Per ASTM Standard

7. Microstructure Analysis

Metallurgy is a branch of materials science that deals with the study of metallic materials, especially metals and alloys at a micro structural level, and a study of the structure-property relationship. Metallurgical analysis and evaluations are the fundamental steps in any routine failure analysis study related to metals and alloys.

a. **Metallurgical and Microstructural Analysis Techniques**

1. Scanning Electron Microscopy (SEM)

2. Transmission Electron Microscopy (TEM)
3. Scanning Probe Microscopy (SPM)
4. Atomic Force Microscopy (AFM)
5. Inverted Microscope
6. Infrared Microscopy
7. Optical Microscopy
8. Macro-Photography

b. Microstructure Analysis of Specimen

1. AZ31 Specimen

The microstructural analysis were conducted on inverted microscope under different magnification level and condition

i. Unetched condition

At 100 x magnification:

Longitudinal section

Figure No.5 Microstructure of AZ31 Alloy at 100 X Magnification

For the above conditions the analysis was done and the following observations were recorded

1. Weld zone visible w. r. t Al- base metal.
2. Weld zone showing as cast structure
3. Porosity and cracks not seen.
4. Good contrast ofAluminium plus silicon eutectic fine grained structure of base al-alloy seen.

ii. Etched with Keller's Reagent

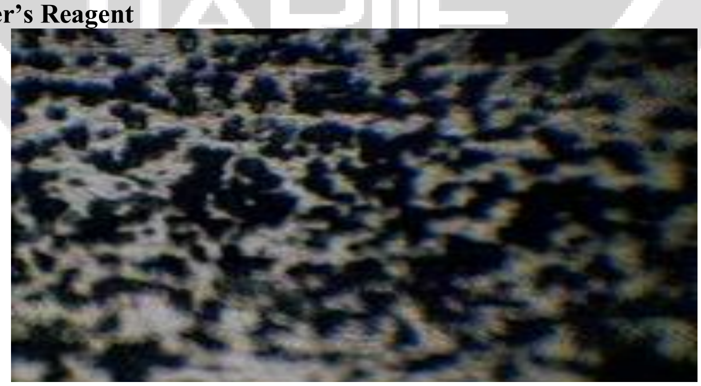

Figure No.6 Microstructure of AZ31 Alloy at 250 X Magnification

For the above conditions the analysis was done and the following observations were recorded

1. Weld structure satisfactory.
2. Properly fused with base metal.

2. Microstructure of AZ91 Specimen

i.Unetched Condition

At 100 X Magnification
Cross Section

Figure No.7 Microstructure of AZ91 Alloy at 100 X Magnification

For the above conditions the analysis was done and the following observations were recorded

1. Weld zone visible w. r. t Al- base metal.
2. Weld zone showing as cast structure
3. Porosity and Cracks Not Seen.

ii.Etched With Keller's Reagent
At 250 X Magnification
For the above conditions the analysis was done and the following observations were recorded
Fully As Cast Structure Seen.
As Cast Structure of Weld.

8. Conclusion

-The welding of magnesium alloy is possible by using friction stir welding process. The different mechanical properties of base material joint were found as per the experimentation.
-The maximum strength of joint is found at 1400rpm rotational speed and 70mm/min transverse speed of AZ31 alloy.
-From the microstructure analysis in the welded joint the materials is properly mixed and there is no pores and having good quality of welding.

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