Friction stir welding parameter otimization using UTM testing and microstructure study

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ABSTRACT

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 aluminum and its alloys. Most of the efforts done in FSW research and development have been performed to optimize the process for joining aluminum and its alloys. We are going to manufacture this base material and going through its FSW leads to observe its microscopic behavior. To evaluate the Mechanical Properties of welded joint of Aluminum alloy (Al 6061) specimen by adopting the Friction stir welding method of solid joining process by manufacturing the tool for welding the selected specimen and weld the same specimen by using oxy-acetylene gas welding process. Study the microstructure and Tensile strength analysis of welded joint specimen and evaluate the welding process is suitable for join the aluminum alloy 6061.[5]

Keyword: Alloy materials, FSW, optimization.

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1. INTRODUCTION

Welding is a fabrication process used to join materials, usually metals or thermoplastics, together. During welding, the work pieces to be joined are melted at the joining interface and usually a filler material is added to form a weld pool of molten material that solidifies to become a strong joint. In contrast, Soldering and Brazing do not involve melting the work piece but rather a lower melting point material is melted between the work pieces to bond them together.[2]

1.1 Types of Welding

In order to welds a material there are many techniques have been used in a industry. Some of important welding techniques are as below.

1.1.1 Arc Welding - Arc welding is a welding process, in which heat is generated by an electric arc struck between an electrode and the work piece. Electric arc is luminous electrical discharge between two electrodes through ionized gas.[2]

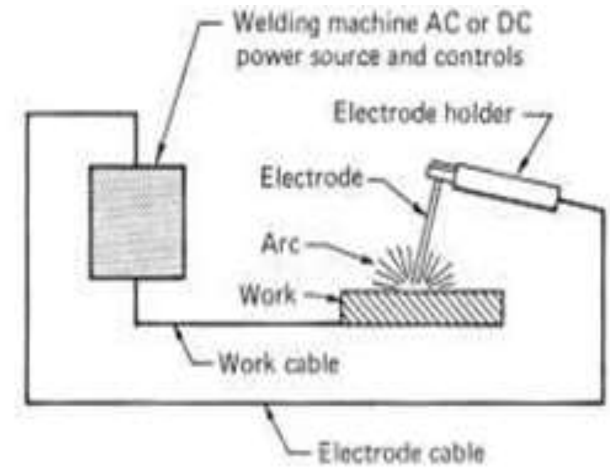

Figure 1 Arc Welding[2]

1.1.2 Resistance Welding-

Resistance Welding is a welding process, in which work pieces are welded due to a combination of a pressure applied to them and a localized heat generated by a high electric current flowing through the contact area of the weld. Heat produced by the current is sufficient for local melting of the work piece at the contact point and formation of small weld pool. Time of the process and values of the pressure and flowing current, required for formation of reliable joint, are determined by dimensions of the electrodes and the work piece metal type.

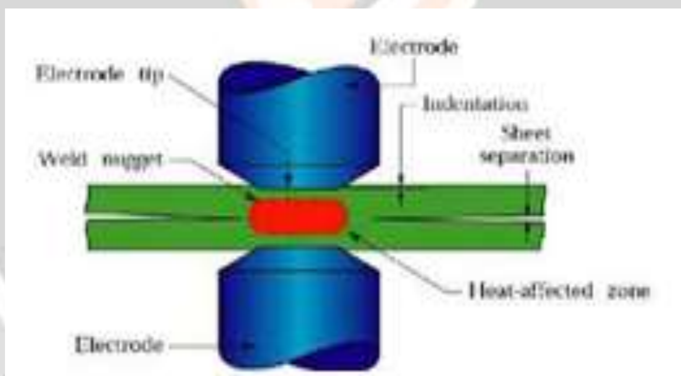

Figure 2 Resistant Welding[3]

1.1.3 Electron Beam Welding- Electron Beam Welding is a welding process utilizing a heat generated by a beam of high energy electrons. The process is carried out in a vacuum chamber at a pressure of about $2*10^{-7}$ to $2*10^{-6}$ psi (0.00013 to 0.0013 Pa). Such high vacuum is required in order to prevent loss of the electrons energy in collisions with air molecules.

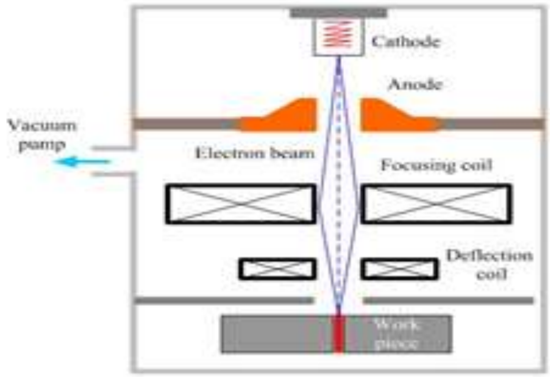

Figure 3 Electron Beam Welding[2]

1.1.4 Laser Welding- Laser Welding (LW) is a welding process, in which heat is generated by a high energy laser beam targeted on the work piece. The laser beam heats and melts the work pieces edges, forming a joint. Solidification of the weld pool surrounded by the cold metal is as fast as melting. Since the time when the molten metal is in contact with the atmosphere is short, no contamination occurs and therefore no shields (neutral gas, flux) are required. The joint in Laser Welding (Laser Beam Welding) is formed either as a sequence of overlapped spot welds or as a continuous weld. Laser Welding is used in electronics, communication and aerospace industry, for manufacture of medical and scientific instruments, for joining miniature components. As shown in figure 4.

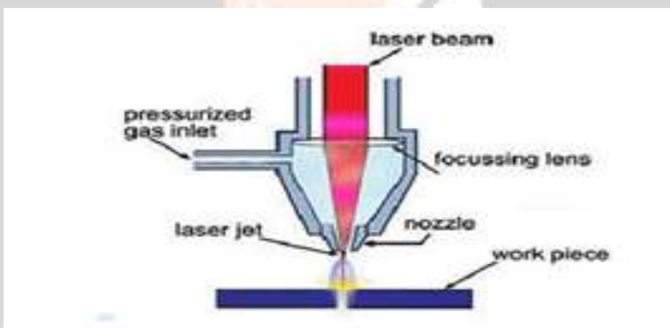

Figure 4 Laser Welding[4]

1.1.5 Solid State welding- Solid State Welding is a welding process, in which two work pieces are joined under a pressure providing an intimate contact between them and at a temperature essentially below the melting point of the parent material. Bonding of the materials is a result of diffusion of their interface atoms.

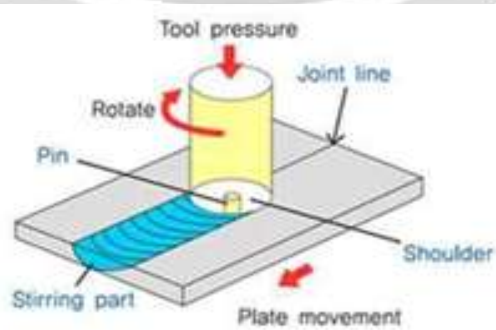

Figure 5 Solid state welding[2]

1.1.6 Oxy-acetylene Welding- Oxygen/Acetylene welding, or "Gas Welding", is a process which relies on combustion of oxygen and acetylene. When mixed together in correct proportions within a hand-held torch or blowpipe, a hot flame is produced with a temperature of about 3,200°C. The chemical action of the oxy/acetylene flame can be adjusted by changing the ratio of the volume of oxygen to acetylene, using the valves on the torch or blowpipe.

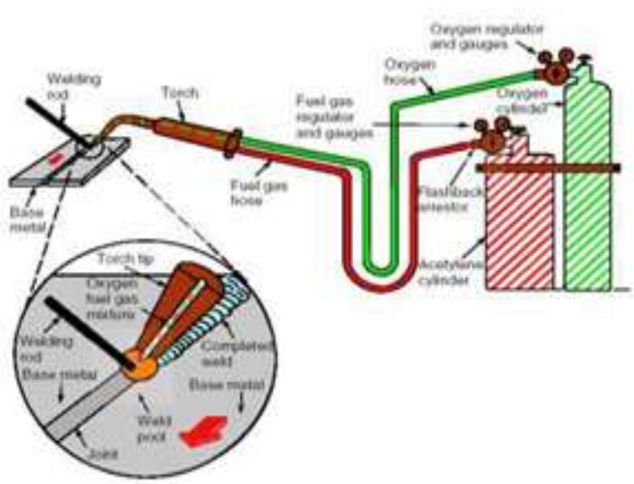

Figure 6 Oxy-acetylene Welding[2]

1.2 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 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 oftener and mixed.

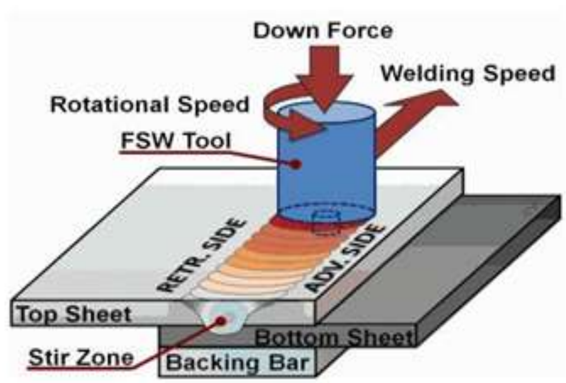

Figure 7 Schematic Diagram of Friction Stir Welding[2]

FSW is considered to be the most significant development in metal joining. As compared to the conventional welding methods, FSW consumes considerably less energy. No gas or flux is used, thereby making the process environmentally. The joining does not involve any use of filler metal and therefore any aluminum alloy can be joined without concern for the compatibility of composition, which is an issue in fusion welding. When desirable, dissimilar aluminum alloys and composites can be joined. This joining process involves rotating tool consisting of a shoulder and probe. The shoulder of the tool applies a downward pressure on the work piece surface which plastics material around the probe as shown in figure 7. And generates the heat through the friction and causes the plastic deformation in a relatively thin layer under the bottom surface of shoulder.

1.3 Principle

The principle of the friction stir welding (FSW) is the rotating pin (tool) is pushed into the material until shoulder meets the work piece surface this causes the material to plasticize due to heating by frictional contact of the tool shoulder and the work piece then tool moved forward and the joint is formed, the process is finished when the tool is retracted from the work piece.

Figure 8 Working principle[4]

2. PROBLEM STATEMENT

To evaluate the Mechanical Properties of welded joint of Aluminum alloy (Al 6061) specimen by adopting the Friction stir welding method of solid joining process by manufacturing the tool for welding the selected specimen and weld the same specimen by using oxy-acetylene gas welding process. Study the microstructure and Tensile strength analysis of welded joint specimen and evaluate the which welding process is suitable for join the aluminum alloy 6061.

2.1 Objective:-

Following objectives will be achieved during this project work.

1. To manufacture of H13 taper tool for welding.
2. To weld the specimen by friction stir welding.
3. To weld the same specimen by oxyacetylene welding.
4. To perform micro structural study of welded joint
5. To take tensile testing on UTM.
6. To find out which welding process is suitable.
7. To develop environmental and human safe welding process.

3. BASE MATERIAL SELECTION

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 aluminum and its alloys. Most of the efforts done in FSW research and development have been performed to optimize the process for joining aluminum and its alloys. A group of TWI Industrial Members demonstrated that the following aluminum alloys could be successfully friction stir welded to produce high integrity welds within defined parametric tolerances: 2000 series aluminum (Al-Cu), 5000 series aluminum (Al-Mg), 6000 series aluminum (Al-Mg-Si), 7000 series aluminum (Al-Zn) and 8000 series aluminum (Al-Li). In the case of different alloys, joining aluminum and steel alloys is of significant importance, and recently Honda Company has successfully performed such welding in a vehicle suspension system for mass production. In terms of high-temperature materials, FSW has been a successful of alloys and materials like,

1. Aluminum and its alloys
2. Copper and its alloys
3. Titanium and its alloys
4. Magnesium alloys
5. Zinc
6. Plastics
7. Mild steel
8. Stainless steel
9. Nickel alloys

In the process of friction stir welding the material selection is basic part. From the literature review, there are large number of materials were used for this process. From the various alloys of Al 6061 are selected because this alloys having low density as compare to steel so it is lighter weight, this material is having also good strength, ductility and corrosion resistance. It is available in the sheets and round bars also. We are taking material in the form of rectangular section in our project work.

4. OPERATING MACHINE

4.1 FSW Machine

Friction Stir Welding (FSW) is a solid-state joining process that creates extremely high-quality, high-strength joints with low distortion. A non-consumable spinning tool bit is inserted into a work piece. The rotation of the tool creates friction that heats the material to a plastic state. As the tool traverses the weld joint, it extrudes material in a distinctive flow pattern and forges the material in its wake. The resulting solid phase bond joins the two pieces into one.

Figure 9 FSW machine[6]

4.2 Universal Testing Machine

A universal testing machine, also known as a universal tester, materials testing machine, materials test frame or tensile strength tester is widely used to test the tensile stress and compressive strength of materials. A UTM

(Universal Tensile Machine), also known as tension test, is probably the most elementary type of mechanical test you can perform on the material. Tension tests are simple, relatively economical, and fully standardized. UTM Machine to Perform Tensile Test The strength of material is the prime factor that explains the quality of the material. The strength refers to the ability of material to resist loads without failure because of excessive stress or deformation. The strength of the materials can be determined easily with Tensile Test.

Figure 10 UTM Machine work[7]

The UTM Machine (Universal Testing Tester) gives highly accurate force measuring system for testing a variety of materials, components, and structures. Load cells, grips, fixtures can be interchanged easily to perform different tests like: Flexural, Elongation, Compression Coefficient of Friction, Peeling & bonding strength. Measurement is done using a tensile tester by applying a constant rate of elongation to the test strip. The control panel is an integral constituent of the testing system, decreasing setup time and increasing testing efficiency through the use of display helps to record the load and extension of the sample. Tests can be set up and run directly from the control panel. As the machines have to go through a number of testing methods, there is a need that machine have to be calibrated on the routine basis, which ensures reliability & durability; it is advised that well-known manufacturer must be looked for universal testing machines.

Work to be done in Stage II:-Following path is followed for the proceeding project work for project stage II

Table 1 Probable work in project stage II

Sr. No.	Month	Task to be done
1	November 2018	Review research paper proceeding and paper publication on project stage I
2	December 2018	Base material selection and manufacturing of fixture for the same for Friction Stir Welding.
3	January 2019	Welding of different material and testing of weld under UTM.
4	February 2019	Microstructure study of different weld and selection of proper weld as per different weld parameter which selected by Taguchi approach.
5	March 2019	Final research paper proceeding and paper publication on project stage II.
6	April 2019	Report writing with guidance from project guide and final presentation preparation.

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