

Experimental Investigation on Aluminium Alloy 6061-T6 Using Multi Profile Tool by Friction Stir Welding

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ABSTRACT: Friction stir welding (FSW) is a relatively new solid-state joining process. It is an emerging solid state joining process in which the material that is being welded does not melt and recast. 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. This paper focuses on process parameters that are required for producing effective friction stir welding joints by using two types of tool pin profile for the welding of Aluminum alloy 6061-T6 and to find out the best tool pin profile.

KEYWORDS: Friction stir welding, Aluminum alloy 6061-T6, multi profile tool.

1. INTRODUCTION

Aluminum alloys are important for the fabrication of components and structures which require high strength, low weight or electric current carrying capabilities to meet their service requirements. Among all aluminum alloys, AA 6061 alloy plays major role in the aerospace industry in which magnesium and silicon are the principal alloying elements. It is widely used in the aerospace applications because it has good formability, weldability, machinability, corrosion resistance and good strength compared to other aluminum alloys. When using the conventional arc welding techniques, long butt or lap joints between AA 6061 and other aluminum alloys are particularly difficult to make without distortion because of high thermal conductivity and special welding procedures and high levels of welder skill are generally required.

The more specialist laser and electron beam techniques can overcome the weld distortion and skill problems, but tracking of very long butt joints is difficult. Moreover, all fusion techniques can cause loss of alloying elements through evaporation and often these have to be replaced by the addition of special filler material to achieve welds which satisfy service requirements. Furthermore, some aluminum alloys cannot be fusion welded. Fusion welding of aluminum alloys poses certain problems like porosity, distortion due to high thermal conductivity and solidification shrinkage. AA 6061 Aluminum alloy cannot be TIG welded without filler wire because it leads to solidification cracking due to its chemistry. In the present work an attempt is made to study the feasibility of joining AA6061 aluminum alloy by friction stir welding (FSW) technique. Friction Stir Welding (FSW) developed in the year 1991 at The Welding Institute (TWI) in UK is a solid state joining process, meaning there is no melting involved in joining the two work pieces and is used for joining aluminium alloys. Friction Stir Welding can be used to produce butt, corner, lap T, spot, fillet, and hem joints, as well as to weld hollow objects, such as tanks and tubes/pipes, stock with different thickness, tapered sections and parts with 3-Dimensional contours. The technique can produce joints utilizing equipment based on traditional machine tool technologies, and it has been used to weld a variety of similar and dissimilar alloys. Replacement of fastened joints with Friction Stir welded joints can lead to significant weight and cost savings, attractive propositions for many Industries.

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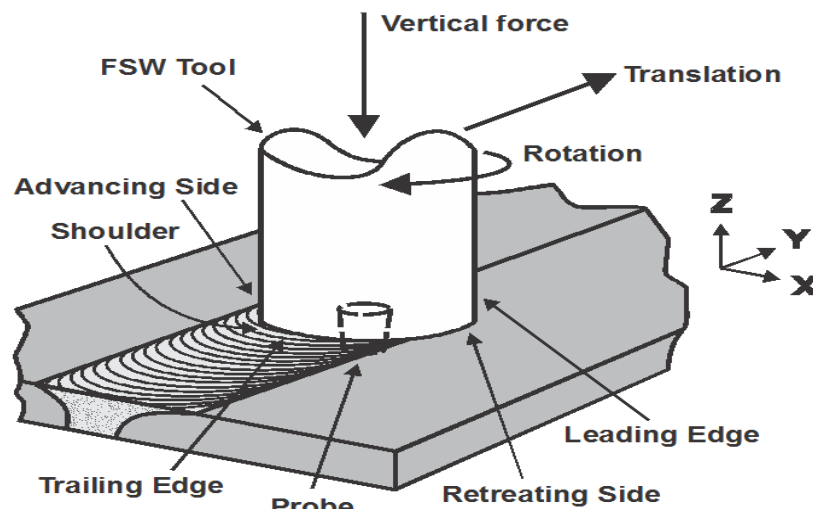


Fig.1.1 Friction Stir Welding

II. TOOL SELECTION

A friction stir welding (FSW) tool is obviously a critical component to the success of the process. The tool typically consists of a rotating round shoulder and a threaded cylindrical pin that heats the workpiece, mostly by friction, and moves the softened alloy around it to form the joint. Since there is no bulk melting of the workpiece, the common problems of fusion welding such as the solidification and liquation cracking, porosity and the loss of volatile alloying elements are avoided in FSW. These advantages are the main reasons for its widespread commercial success for the welding of aluminum and other soft alloys.

2.1 TOOL PROPERTIES

High Carbon High Chromium Steel (HCHCR)

Carbon steels which successfully undergone heat-treatment have a carbon content in the range of 0.30 to 1.70% by weight are commonly called higher carbon steel. HCHCR steel has a varying chemical composition which results in its mechanical and microstructural properties. They possess high hardenability and wear resistance and heat softening resistance

2.2 WORKPIECE MATERIAL

Aluminum Alloy 6061-T6

Aluminium alloys with a wide range of properties. Among all aluminum alloys, AA 6061 alloy plays major role in the aerospace industry in which magnesium and silicon (0.3-1.5 w%, Si, Mg) are the principal alloying elements. Aluminum alloys 6061 is a medium to high strength heat-treatable alloy with a strength higher than 6005A. It has very good corrosion resistance and very good weldability although reduced strength in the weld zone. It is widely used in the aerospace applications because it has good formability, weldability, machinability, corrosion resistance, and good strength compared to other aluminum alloys.

III. EXPERIMENTAL METHOD

- The work pieces are clamped on the bed using fixtures.
- The work pieces must be clamped tightly on to the bed.

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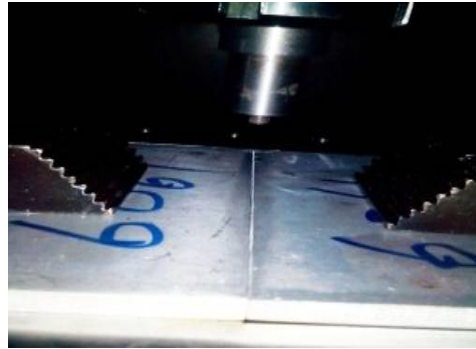


Fig 3.1 Clamping of Work piece and tool

- The tool is fixed on the tool head chuck very firmly with the probe facing downward.
- The rotational speed is set to 800 rpm.
- Now the tool is vertically moved downwards towards the work piece. When the tool starts to touch the surface of the work piece due to the friction between the tool profile and the work piece heat is generated between them.
- This heat melts the aluminum surface and due to this deformation the two work pieces get welded to each other when the bed is moved laterally.
- The feed rate is given at 85mm/min to obtain high strength weld.
- Then the work piece and tool are removed.
- Then the next set of work piece is set on the bed
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Fig.3.2 Welding of the work piece

IV. RESULTS AND DISCUSSION

4.1 TENSILE TEST

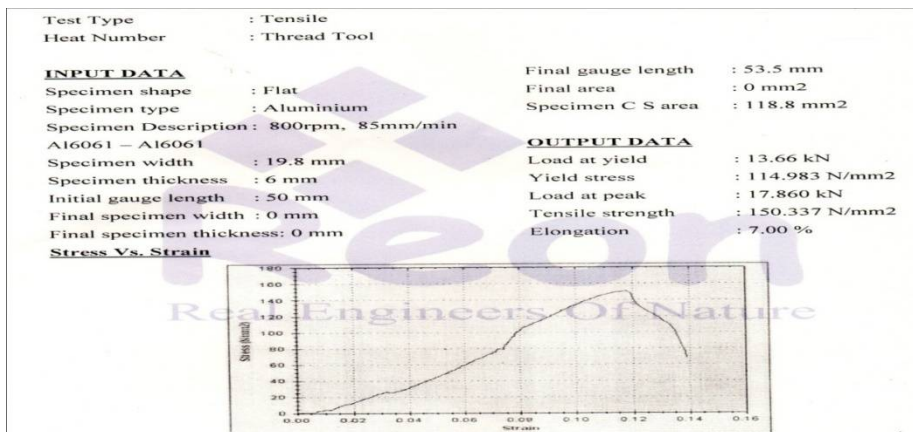
Tensile testing utilizes the classical coupon test geometry as shown below and consists of two regions: a central region called the gauge length, within which failure is expected to occur, and the two end regions which are clamped into a grip mechanism connected to a test machine

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4.1.1 RESULTS



4.2 ULTRASONIC TESTING

Ultrasonic testing (UT) uses high frequency sound energy to conduct examinations and make measurements. Ultrasonic inspection can be used for flaw detection/evaluation, dimensional measurements, material characterization, and more. A transducer generates high frequency ultrasonic energy and this sound energy propagates through the material in the form of waves. The reflected wave signal is transformed into an electrical signal by the transducer and is displayed on a screen.

4.2.2 RESULTS

Reference Procedure Specification : ASME SEC V				
Surface Condition : Medium Smooth		Surface Temp : At room temp		Scanning : Welded Area & HAZ
Equipment & Technique				
Model : Modsonic – Einsten II	SL No : E 3253 - 0212		Manufacturer : Modsonic	
Couplant : Grease	Cable Type : Big Lemo to Small Lemo		Technique : A Scan	
Basic Calibration Block : V1 of IIW				
Range : 0 to 25 mm Mode: Single				
Probe Angle	0°	45°	60°	70°
SL No	29761			
Dimension	10 Dia			
Frequency	4 MHz			
Velocity m/s	6320			
Sensitivity	1.5 mm			
Ref gain	21.0 dB			
Scan gain	29.5 dB			
Range	0 – 25mm			

Heat No	Specimen Name	Results
6061 – SQ	Aluminium Plate	Occurred porosity in four places and the depths were 3.1mm, 3.3mm, 3.4mm & 3.4mm
6061 – TD	Aluminium Plate	Occurred Lack fusion and the depth is 3.4mm. Length is 25mm.

V. CONCLUSION & SCOPE FOR FUTURE WORK

From the various tests involving the tensile test and ultrasonic inspection of the welded aluminum plates using FSW we have observed that the plates welded using threaded profile pin has ability to withstand high tensile strength than that of the plates welded using square pin profile. Also the ultrasonic testing showed that the plates welded using threaded

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profile pin has less cracks formed. Thus we conclude that threaded tool pin profile provides the best weld when compared to that of the square tool pin profile and also that Friction stir welding is the best suited one for the welding of aluminum alloy 6061-T6. In the future we want to perform welds of dissimilar materials of different grades of aluminum using different tool pin profiles and different feed rates and different rpm's and to analyze the various weld properties.

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