ANALYSIS ON FRICTION STIR WELDED 6082 AND 8011 ALUMINUM ALLOYS

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ABSTRACT

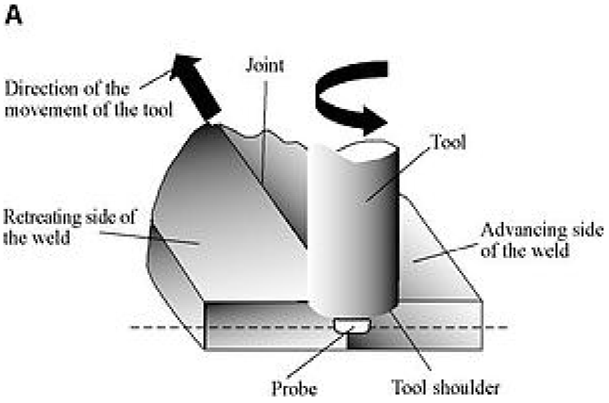
In this study, two dissimilar aluminium alloys are joined together through friction stir welding and their micro structure and mechanical properties like yield strength, tensile strength, shear strength and elastic module etc. and their chemical properties and chemical composition are analysed. Friction 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. Tensile strength test is done on friction stir welded material and graph is plotted for three specimens which gives the result that yield strength for the welded area is good than the other welding processes. The welded areas possess good strength and composition so it can be used for many processes as replacement for already used aluminium alloys.

INTRODUCTION

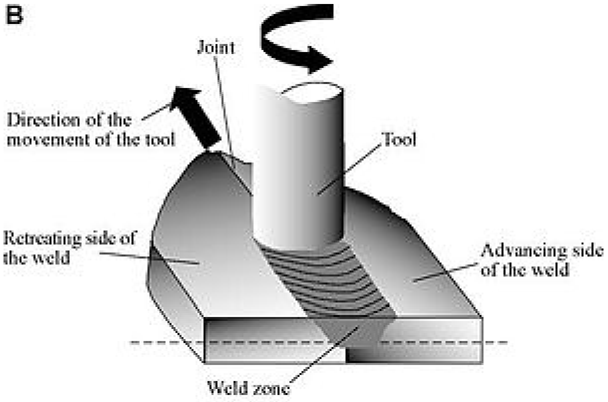
Friction-stir Welding

Friction-stir welding (FSW) is a solid-state joining process that uses a third body tool to join two facing surfaces. Heat is generated between the tool and material which leads to a very soft region near the FSW tool. It is primarily used on aluminium and extruded aluminium (non-heat treatable alloys) and on structures which need superior weld strength without a post weld heat treatment. It was invented and experimentally proven at The Welding Institute UK in December 1991. TWI holds patents on the process, the first being the most descriptive.

Principle of operation



Two discrete metal work pieces butted together, along with the tool (with a probe).



The progress of the tool through the joint, also showing the weld zone and the region affected by the tool shoulder. A constantly rotated non-consumable cylindrical-shouldered tool with a profiled probe is transversely fed at a constant rate into a butt joint between two clamped pieces of butted material. The probe is slightly shorter than the weld depth required, with the tool shoulder riding atop the work surface. Frictional heat is generated between the wear-resistant welding components and the work pieces. This heat, along with that generated by the mechanical mixing process and the adiabatic heat within the material, cause the stirred materials to soften without melting. As the pin is moved forward, a special profile on its leading face forces plasticized material to the rear where clamping force assists in a forged consolidation of the weld. This process of the tool traversing along the weld line in a plasticized tubular shaft of metal results in severe solid state deformation involving dynamic re crystallization of the base material.

Advantages and Limitations

Potential advantages of FSW over conventional fusion-welding processes are Good mechanical properties, Safety, Easily automated on simple milling machines, generally good weld appearance and minimal thickness, less consuming of tools, minimum welding area, Low environmental impact, General performance and cost benefits from switching from fusion to friction. Some disadvantages are Exit hole left when tool is withdrawn, large down forces required with heavy-duty clamping necessary to hold the plates together, less flexible than manual and arc processes, often slower traverse rate than some fusion welding techniques.

Important Welding Parameters

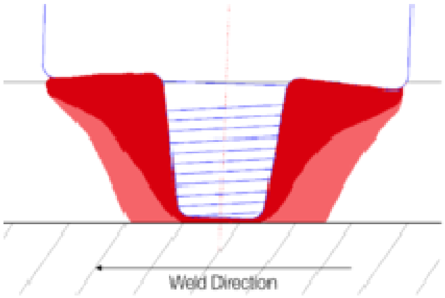
1. *Tool design*

The design of the tool is a critical factor as a good tool can improve both the quality of the weld and the maximum possible welding speed. It is desirable that the tool material be sufficiently strong, tough, and hard wearing at the welding temperature.

2. *Tool rotation and traverse speeds*

There are two tool speeds to be considered in friction-stir welding; how fast the tool rotates and how quickly it traverses the interface. These two parameters have considerable importance and must be chosen with care to ensure a successful and efficient welding cycle. The relationship between the welding speeds and the heat input during welding is complex but, in general, it can be said that increasing the rotation speed or decreasing the traverse speed will result in a hotter weld. In order to produce a successful weld it is necessary that the material surrounding the tool is hot enough to enable the extensive plastic flow required and minimize the forces acting on the tool. If the material is too cold then voids or other flaws may be present in the stir zone and in extreme cases the tool may break.

3. *Tool tilt and plunge depth*



A drawing showing the plunge depth and tilt of the tool. The tool is moving to the left. The plunge depth is defined as the depth of the lowest point of the shoulder below the surface of the welded plate and has been found to be a critical parameter for ensuring weld quality. Plunging the shoulder below the plate surface increases the pressure below the tool and helps ensure adequate forging of the material at the rear of the tool. Tilting the tool by 2–4 degrees, such that the rear of the tool is lower than the front, has been found to assist this forging process.

4. *Welding forces*

During welding a number of forces will act on the tool. A downwards force is necessary to maintain the position of the tool at or below the material surface. The traverse force acts parallel to the tool motion and is positive in the traverse direction. The lateral force may act perpendicular to the tool traverse direction and is defined here as positive towards the advancing side of the weld. Torque is required to rotate the tool, the amount of which will depend on the down force and friction coefficient (sliding friction) and/or the flow strength of the material in the surrounding region

5. *Flow of material*

Early work on the mode of material flow around the tool used inserts of a different alloy, which had a different contrast to the normal material when viewed through a microscope, in an effort to determine where material was moved as the tool passed. The data was interpreted as representing a form of in-situ extrusion where the tool, backing plate and cold base material form the "extrusion chamber" through which the hot, plasticized material is forced. In this model the rotation of the tool draws little or no material around the front of the pin instead the material parts in front of the pin and passes down either side.

6. Generation and flow of heat

Heat generation during friction-stir welding arises from two main sources: friction at the surface of the tool and the deformation of the material around the tool. The heat generation is often assumed to occur predominantly under the shoulder, due to its greater surface area, and to be equal to the power required to overcome the contact forces between the tool and the work piece. The contact condition under the shoulder can be described by sliding friction, using a friction coefficient μ and interfacial pressure P, or sticking friction, based on the Interfacial shear strength at an appropriate temperature and strain rate. Mathematical approximations for the total heat generated by the tool shoulder Q_{total} have been developed using both sliding and sticking friction models:

$$Q_{\text{total}} = \frac{2}{3}\pi P \mu \omega \left(R^3_{\text{shoulder}} - R^3_{\text{pin}}\right)$$

(Sliding)

$$Q_{\text{total}} = \frac{2}{3}\pi \tau \omega \left(R^3_{\text{shoulder}} - R^3_{\text{pin}}\right)$$

(Sticking)

Where ω is the angular velocity of the tool, $R_{shoulder}$ is the radius of the tool shoulder and R_{pin} that of the pin.

Welding Machine

Welded materiel

Welding zone

RESULT AND GRAPHS

Aluminium (8011)

Chemical properties:
Test method: OES-ASTM E-1251-11

Fe%	Si%	Mn%	Cu%	Ni%	Cr%	Ti%
0.180	0.234	0.300	<0.001	<0.01	<0.001	0.011
Sn%	**V%**	**Co%**	**Zn%**	**Pb%**	**Mg%**	**Al%**
0.004	0.008	<0.002	3.877	0.006	1.450	93.910

Mechanical properties :

S.No	Characteristic Test	Findings
1	Hardness –[HV1]	101.0,101.8,101.7,102.1,103.6

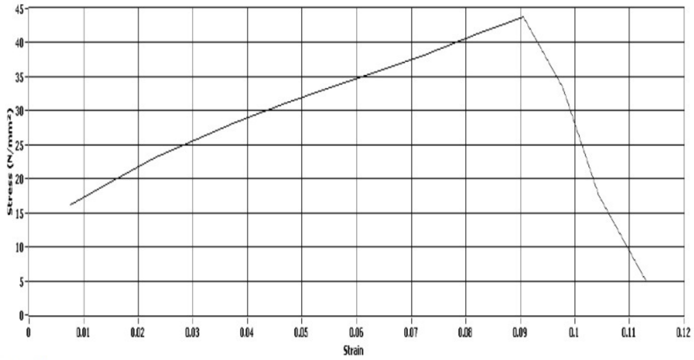
Aluminium (6082)

Chemical properties:
Test method: OES-ASTM E-1251-11

Fe%	Si%	Mn%	Cu%	Ni%	Cr%	Ti%
0.213	0.029	<0.01	<0.001	<0.01	<0.001	0.017
Sn%	**V%**	**Co%**	**Zn%**	**Pb%**	**Mg%**	**Al%**
<0.002	0.007	<0.002	<0.005	0.002	<0.004	99.711

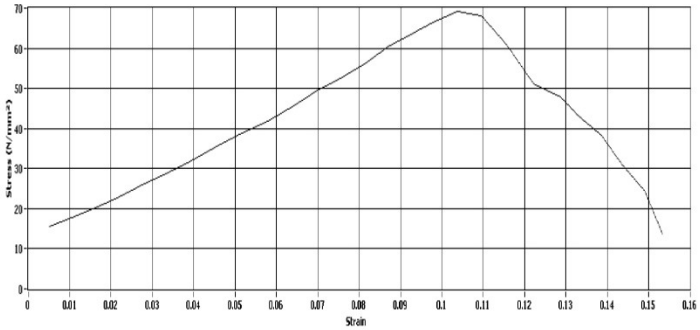
Mechanical properties :

S.No	Characteristic Test	Findings
1	Hardness –[HV1]	36.7,36.4.36.6,36.4,35.9



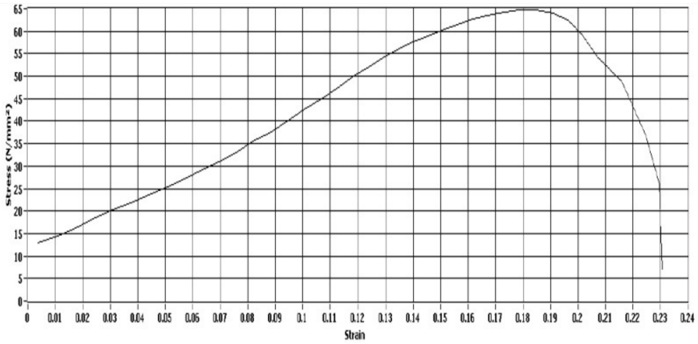
Results

Fmax	1.90 KN
UTS	43.81 MPa
% EL	2.37 %
Yield Stress(Ys)	41.05 MPa



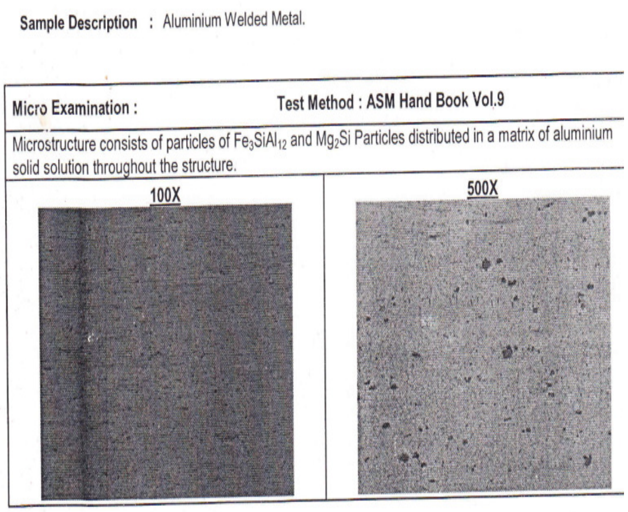
Results

Fmax	2.71 KN
UTS	69.19 MPa
% EL	7.13 %
Yield Stress(Ys)	60.32 MPa



Results

Fmax	2.88 KN
UTS	64.82 MPa
% EL	9.20 %
Yield Stress(Ys)	29.28 MPa



Sample Description : Aluminium Welded Metal.

Micro Examination : Test Method : ASM Hand Book Vol.9

Microstructure consists of particles of Fe_3SiAl_{12} and Mg_2Si Particles distributed in a matrix of aluminium solid solution throughout the structure.

RESULT

Friction stir welding is done successfully on dissimilar aluminium alloys Al 6082 and Al 8011 and their chemical properties were tested and analysed which provides details that welded area contains good grain structure and chemical properties. Tensile strength test is done on friction stir welded material and graph is plotted for three specimens which gives the result that yield strength for the welded area is good than the other welding processes. The welded areas possess good strength and composition so it can be used for many processes as replacement for already used aluminium alloys.

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