TITLE:Review on Friction Stir Welding of Aluminium - Lithium Alloy

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ABSTRACT

Objective:Friction Stir Welding (FSW) is a relatively new solid state welding technique for similar and dissimilar materials, especially on current intrest with aluminium and lithium alloys. Methods/Analysis:Friction stir welding with aluminium and lithium alloys are reviewed on this paper. The basic principle of FSW are described, followed by process parameters study which affects the weld strength. Conclusion / Application:It is demonstrated that FSW of Aluminium and Lithium alloy is becoming an emerging technology with numerous commercial applications.

Keywords*:Aluminium –Lithium alloys, Friction stir welding, Microstructure, Mechanical properties.*

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1. INTRODUCTION

In recent times, focus has been on developing fast, efficient processes that are environment friendly to join two dissimilar materials.The spotlight has been turned on Friction Stir Welding as a joining technology capable of providing welds that do not have defects normally with Fusion welding processes[12,13]. FSW was invented by Wayne Thomas at TWI (THE WELDING INSTITUTE), and first patent applications were filed in the UK in December 1991.

The combination of Aluminium-Lithium alloy has low density and high modulus[19,],which can be useful for lightweight components of aerospace vehicles. Lithium has hygroscopic property which causes porosity ,cracking and low joint efficiency[2,3].

Alloys show an unusual boundry cracking phenomenon which is related with grains of equiaxed zone that forms via solidification mechanism. Combination of Li-Cu in the interface liquid lowers the solidification tempreture of liquid. Due to this hot cracking occurs[4]. Therefore FSW is very important and is choosen to avoid solidification cracking for joining of this alloy. Using FSW , rapid and high quality welds of 2xx and 7xx series alloys[20], traditionally considered unweldable, are now possible.

2. PROCESS

Combined action of frictional heating and mechanical deformation due to a rotating tool. A cylindrical shouldered tool with a profile pin is inserted into the joint line. Heat is generated primarily by friction between the rotating-translating tool, and the shoulder of which rub against the workpiece .Plates are strongly clamped with a backing bar below the weld line.If the plates are not clamped ,then the plates will try to separate each other.Here thre is no question of throwing off material, it is a blend heat which is going under force.And there is a shoulder on the top which is also rubbing against the plate surface.The root gap has to be zero.

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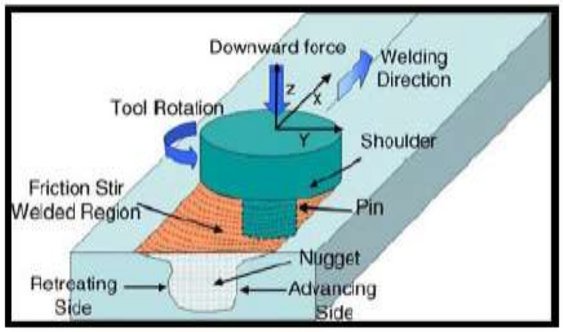


Figure 1. Schematic illustration of Friction Stir Welding[9].

As shown in figure; the cylindrical member is the tool which has a kind of nib or pin at the below. The intersection of the cylinder and pin is the shoulder. There are two pieces of plates with zero root gap clamped on both sides such that they don't move out. And a downward force is applied on the tool which is rotating having a suitable amount of torque. The transeverse force is provided to the tool so that it can move ahead. So while it is rotating a downward force has to be provide such that a proper friction can takes place and as well as the pin can plunge through . So we need higher downward force to have it plunge through. But obviously once the friction starts then the stress required is less. So had there been no friction .We can put the nib inside and then we have to provide a forward motion to the tool.that means a transeverse force is needed which will push through the metal ,but obviously the metal is in plastified state.so it can push through without much higher force. The nib forced into the plates until the shoulder contacts the plate surface. A downward forging pressure from the shoulder helps to prevent the expulsion of softened material.When we are pushing it through, this nib is displacing the material. The material try to expel,come out. The shoulder prevents that from happening. The shoulder is made little concave inside, such that it can accommodate the expelled material, and also provides asupplementary frictional heating.It plasticizes a cylindrical metal coloumn around the pin and immediate material under shoulder.As the tool is moved forward material is forced to flow from leading edge to trailing edge.Whatever material is flowing around the tool, it undergoes extreme level of plastic deformation. The total dislocation of the material is taking place. The entire metal is getting it, is because ultimate sort of plastic deformation is when the metal becomes liquid. But here it is just before the liquid state[1].

3. TOOL GEOMETRY

Tool geometry affects the heat generation rate, torque and thermomechanical environment experienced by the tool. The flow of plasticised material in the workpiece is affected by tool geometry.

a) Shoulder Diameter

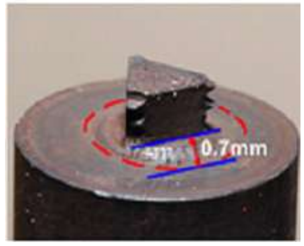
The diameter of the shoulder is important because the shoulder generates most of heat,and is grip on plasticised material largely establishes the material flow field. For a good FSW, The material should be adequately softened for flow , the tool should have adequate grip on plasticized material and total torque and traverse force shouid not be excessive[5].

b) Shoulder Surface:

The nature of tool shoulder surface is an important consideration of tool design. It is found that triangular pin with concave shoulders resulted in high strength spot welds[6,7]. Microstructure, geometry and failure mode of weld may be altered if the tool shoulder choosen is concave rather than flat[8]. It is found that when convex scroll shoulder is used in any constant axial force mode, any increase in plunge depth from its normal value results in greater contact area between shoulder and workpiece[9].

c) Pin (Nib):

The shape of the tool pin influences the flow of plasticized material and affects the weld properties.While the tool shoulder facilited bulk material flow the pin aided a layer by layer material flow .A triangular tool pin increases the material flow compared with cylindrical pin[6]. The axial force on the workpiece material and the flow of material near the tool are affected by the orientation of of threads on the pin surface[10,11].Triangular prism shaped tool pin would be suitable for harder alloys. Tapered pin profile with screw thread produced welds with minimum defects.



a)Cylindrical threaded pin b)Triangular pin

4. WELDING PARAMETERS

1.Downward Force
2.RPM
3.Traverse Force,Travel Speed

Travel rate influences rate of heat input and also affects metal flow around the tool nib. Higher the downward force higher will be the friction heat generation[18] . More the RPM more will be the heat generation. This are the important parameters for FSW. Total heat generation is directly proportional to the RPM and downward force.

4.1 Other Parameters For Heat Generation:

1.Time of indentation of tool
2.Shoulder Radius
3.Shoulder Angle

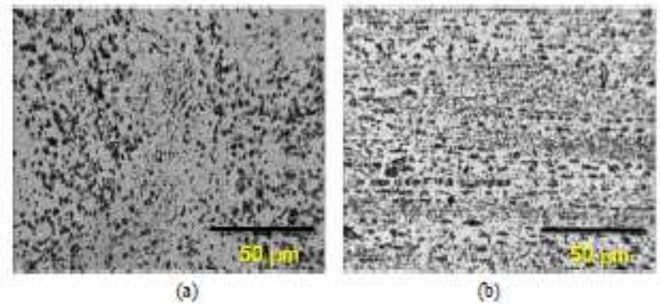
Time of indentation of tool means, the period between the instant the tool contacts the workpiece and the instant the tool begins moving along joint.
Range: 3sec to 5 sec[1].
Because longer it is there it is generating more and more heat, but after some time ,it attains a steady state.
Tool shoulder angle allows a gradual increase of the pressure on the top of the surface of work .It also helps to direct the metal flow.
Tool Angles upto 3 degree are common[1].

4.2 Heat Loss

The primary heat loss is conduction through the tool material ; because there is no inert gas flowing in the thing, such that a conventional loss would be there . There is no much of radiation loss .So heat loss is depends on the material of tool .If the tool material have high thermal conductivity higher will be the heat loss through tool[1].

5. MICROSTRUCTURAL STUDIES:

The figure shows the microstructure of Aliminium-Lithium (AA2195) alloy. Some precipitates are found at grain boundaries. From microstructure it is seen that Grain boundaries are not clearly visible. The precipitates are easy to nucleate at grain boundaries beacause of high dislocation density is suitable for diffusion[14,15].



(a)longitudinal **(b) cross-sectional**

View of AA2195

6.BENEFITS OF FSW

A) Metallurgical Benefits

1. Solid phase process..
2. Low distortion
3. Good dimensional stability..
4. No loss of alloying elements.
5. Excellent mechanical properties in the joint area.
6. Fine recrystallized microstructure.
7. Absence of solidification cracking.
8. Replace multiple parts joined by fasteners.
9. weld all aluminium alloys .
10. Post FSW formability.
11. Absence of porosity , oxidation and other defects related to fusion welding.

B) Environmental Benefits:

1.No shielding gas required.
2.Minimal surface cleaning required eliminate grinding wastes.
3.Eliminate solvents required for degreasing.
4.Consumable materials saving such as rugs wire or any other gases.
5.No harmful emissions.

C) Energy Benefits:

1.Improved materials use (eg: joining different thickness allows reduction in weight).
2.Rate of heat input is less.[1]

7.LIMITATION OF FSW

1.For every thickness of plate a different tool is required.[1]

2.Exit hole is produced at the end of weld.

8. APPLICATIONS

1.Space shuttle gigantic external tank.
2.Shipbuilding industry.
3.Freezer panels.
4.Panels for deck and wall construction.
5.Automotive applications.
6.Bumper Beams.

9.CONCLUSION: The present review has demonstrated the research effort on understanding the effect of process parameters of FSW on aluminium-lithium alloys .All the defects related to fusion welding are eliminated. New Recrystalized grains are formed which improves mechanical properties of joint. Hot cracking problem which always occurs in Al-Li alloys can be eliminated by using FSW process.

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