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Friction Stir Welding of Dissimilar Aluminium alloys AA1100 to AA6101-T6

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Abstract

Friction stir welding (FSW) is primarily used for aluminium. FSW is used to replace rivets joints in the aeronautical industry. AA1100 and AA6101 are the most common aluminium alloys used for electrical busbar applications. In present study FSW of dissimilar aluminium alloys AA1100 and AA6101-T6 of 5mm thick plates was carried out. The FSW trial was carried on vertical machining center and cylindrical profile tool of H13 material was used. Tensile testing of joint is done using computerized UTM.Tensile strength of dissimilar joint is less than the stronger base metal alloy (AA6101-T6) but very nearer to the weaker material (AA1100).

Keywords*:* Friction Stir Welding, Aluminium Alloys, Tensile Strength.

1. Introduction

Friction stir welding (FSW) is the solid state welding process was invented at The Welding Institute (TWI) of the United Kingdom in 1991. Due to the rotational and translational motion of tool shoulder, plunged pin and forging pressure exerted by tool shoulder on the metal pieces joint is formed without fusion and filler material.

AA 1100 Aluminium is 1000 series aluminium alloy. It is pure aluminium with a minimum 99% aluminium content. AA 1100 is widely used in the chemical and food processing industries also used for electrical bus bars and bus bar supports. It is comparatively soft, low strength between all the aluminium alloys. AA 6101 Aluminium is 6000 series aluminium alloy. In 6000 series aluminium is alloyed with magnesium and silicon. Aluminum 6101 alloy has good mechanical strength and high electrical conductivity.Therefore, it is used for electrical bus bar conductor where it requires minimum loss of electrical conductivity and good mechanical properties.T6 is temper designation for solution heat treated and artificially aged to maximum mechanical property levels.

S. Nansaarng et al. [5] studied dissimilar friction stir welded joint of AA1100 and AA6063-T6 aluminium alloy. They investigated the effect of tool rotational speed and welding speed on hardness, ultimate tensile strength, elongation and yield strength using factorial design. They found the maximum of hardness as 82.08 HV, ultimate tensile strength as 100.49 MPa and yield strength as 66.373 MPa.

N. T. Kumbhar et al. [6] studied friction stir welding of two aluminium alloys AA6061 and AA5052 at various combinations of tool rotation speeds and tool traverse speeds. From The microstructural studies, they suggested that there was no rigorous mixing of both materials in the nugget. They found that tensile properties of the FSW AA5052-AA6061 specimens were better than the properties of the softest of the similar friction-stir-welded systems (i.e., FSW AA6061).

Ranjith R. et al. [7] carried out friction stir welding of dissimilar aluminium alloys AA2014 T651 and AA6063 T651. They showed that better interlocking and bonding of materials occurs at 40 tilt angle.They found the tensile strength is better when the tool is offset towards AA2014 side because of complete fusion of harder material.

S. Ravikumar et al. [8] investigated the effects of rotational and welding speeds with the pin profiles on micro hardness distribution and tensile property of the dissimilar Aluminium AA6061-T651 and AA7075-T651 joints. They found that good mixing of both nthe materials joined was obtained at lower welding and higher rotational speed.

There is no work reported on dissimilar Friction Stir Welding of Aluminium alloys AA1100 to AA6101-T6 at lower tool traverse speed 3mm/min. In this study experiment is conducted at 3 mm/min tool travers speed and 1500 rpm tool rotational speed.

2. Experimental Details

In this work frictional stir welded dissimilar Aluminium alloys AA1100 and AA6101-T6 specimens are compared for tensile properties. In this study FSW specimens are prepared at 3mm/min feed rate and at 1500 rpm spindle speed. The plate size of aluminium alloys are same and having 100 mm length, 50 mm width and 5 mm thickness. H13 material is used to manufacture the tools. [9] Tool has pin diameter of 6 millimeter size. Tool dimensions: Shoulder Diameter- 18mm, Pin Diameter- 6mm.

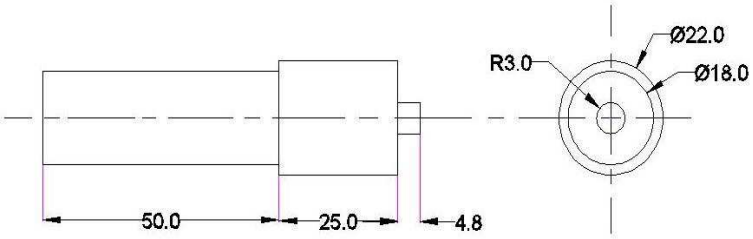

Figure 1: Design of straight cylindrical pin

Following are materials and parameters used for experiment:
Material: AA1100 Aluminium, AA6101-T6 Aluminum
Sheet Thickness: 5mm
Tool: Cylindrical
Spindle Speed: 1500 rpm
Welding Speed: 3mm/min
The FSW process was carried on vertical milling machining centre.
As per test report composition of alloys is as shown in Table 1 and Table 2

Table 1: Composition of AA1100

Element	Al	Si + Fe	Cu	Mg	Mn	Zn	Ti	Ca	Pb	Zr
AA1100	99	0.68	0.2	0	0.001	0.02	0.02	0.002	0.002	0.003

Table 3: Composition of AA6101-T6

Element	Al	Si	Fe	Cu	Mg	Mn	Zn	Ti	Ca	Pb	Zr	Ni
AA6101-T6	Balance	0.5	0.2	0.2	0.5	0	0.025	0.02	0.002	0.002	0.001	0.01

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Workpiece Specification: Plate Length=100mm, Plate Width=50mm,Plate Thickness=5mm
Raw material was cut into the specified dimensions, then machined at the sides in order to make them flat to ensure accurate face-to-face contact at weld joint as shown in Figure2.

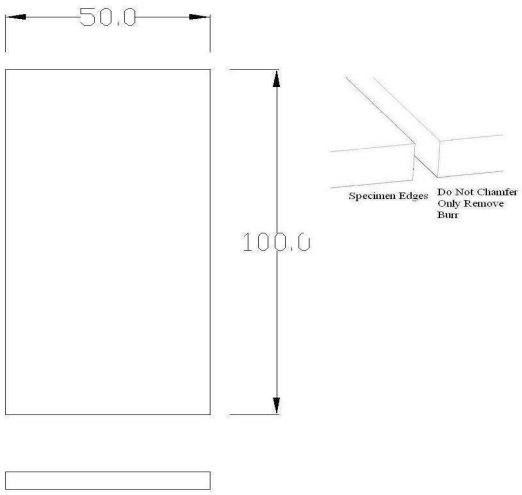

Figure 2: Workpiece Dimensions

At advancing side Aluminium AA6101 –T6 alloy and at retreating side Aluminium AA1100 alloy was kept in fixture. The joint is successfully obtained.The joint is formed as shown in Figure3

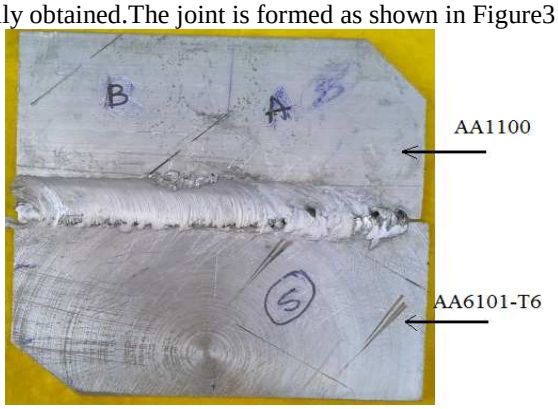

Figure 3: Photograph of Dissimilar joint Aluminium AA1100 and Aluminium AA6101-T6

3.Testing and Analysis

1.Visual Inspection
From Figure3 following are the observations:
a) Dissimilar joint of Aluminium AA1100 to AA6101-T6 found satisfactory in visual inspection.
b) Tunnel like defects are present at the surface of joint.
2.Tensile Test
Tensile testing specimen was made as per the drawing shown in figure4. Care was taken during this stage to align the centre of the weld with the centre of the tensile specimen. Tensile testing was carried out on an UTM.

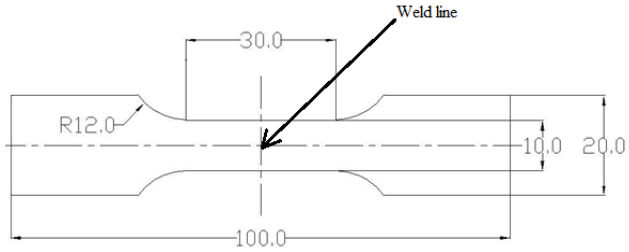

Figure 4: Tensile test specimen [4]

Tensile test results

Following graph shows result of tensile test of the joint.

Figure 5: Graph of Stress vs Strain of Dissimilar Friction Stir Welding Aluminium AA1100 to AA6101-T6

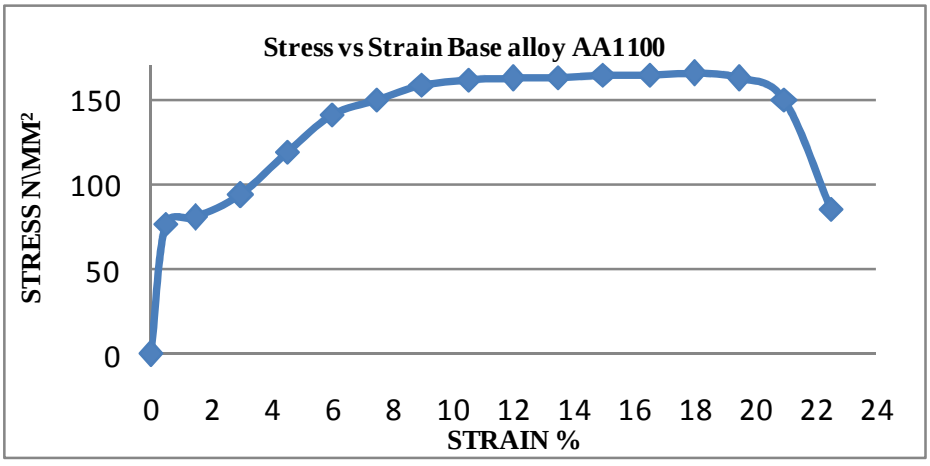

Figure 6: Graph of Stress Vs Strain of Base Alloy AA1100

Figure 7: Graph of Stress Vs Strain of Base Alloy AA6101-T6

Table 3: Comparison of Tensile Strength

Material	Tensile Strength N/mm^2
Dissimilar Joint	153.33
AA6101 –T6 Aluminum	284.4
AA1100 Aluminum	165.60

As seen from figure and table:

1. For Dissimilar Friction Stir Welding Aluminium AA1100 to AA6101-T6 joint Tensile strength for FSW is less than that for both base metals.

4. Conclusion

1)Dissimilar Friction Stir Welding Aluminium AA1100 to AA6101-T6 joint is formed
2)Tunnel like defects are present at the surface of joint.
3)Tensile strength of dissimilar joint is less than stronger base metal alloy (AA6101-T6) but very nearer to weaker material (AA1100) shows that tensile properties of aluminum alloy retained after friction stir welding.
4)Extensive experimentation is required to study effect of parameters on properties of dissimilar Aluminium AA1100 to AA6101-T6 friction stir welded specimen.

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