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FRICTION STIR WELDING OF DISSIMILAR ALUMINIUM ALLOYS (5083 & 6061) – MICROSTRUCTURE & MECHANICAL PROPERTIES

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ABSTRACT

The present investigation aims in assessment of microstructure and mechanical properties of friction stir welded dissimilar Al alloys. A study has been made to influence of microstructure on mechanical properties of Friction stir welding of dissimilar Al alloys 5083 and 6061 due to their range of usage in naval and marine applications. Dissimilar FSWed joints were fabricated by varying the rotation speeds, transverse speed and tool tilt angle and during welding process Al 5083 is placed on advancing side and Al 6061on the retreating side. It is observed that higher mechanical properties are obtained at a rotation speed of 1120 rpm and welding speed of 25mm/min and tool tilt angle 1° due to fine microstructure. The mechanical properties were observed & correlated with the microstructure.

Keywords: 5083 and 6061 Al alloy, Friction stir welding, Microstructure, Tensile Strength.

INTRODUCTION

Friction stir welding (FSW) is considered to be the most significant development in metal joining in a decade and is a ‘‘green’’ technology due to its energy efficiency, environment friendliness, and versatility. Friction-stir welding (FSW) is a solid-state joining process (the metal is not melted) 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 [1]

As compared to the conventional welding methods, FSW consumes considerably less energy. FSW on joining of metals can be seen in. Joining of dissimilar metals by conventional methods results in large plastic deformations, unwanted thermal stresses and poor mechanical properties. FSW offers an efficient solution to this challenging task since the joining takes place much below the melting temperatures and results in less distortion, lower residual stresses and fewer defects. Joining of dissimilar aluminum alloys is gaining research importance by FSW. FSW of Aluminum, Copper and Steel, since the metal is deformed by the frictional heat generated by rotating the tool the stirring action of the pin plasticizes the material and the joint is produced by plastic deformation of the material. The pin not only rotates but also traverses along the length of the weld, enabling to weld the two plates. The tool rotation and weld direction are similar on one side called as Advancing Side (AS) and opposite on the other called as Retreating Side (RS). Due to this in an FSW joint there exists an asymmetry which is the unique characteristic of the joint. By observing the physical phenomenon of the process one can easily understand the important process parameters that influence the strength of the joint.[1] Aluminum 5083 is a high strength wrought alloy in commercial use. The major additive in the alloy is Magnesium. It has good formability and weld ability and retains excellent tensile strength in the weld zone. It has excellent resistance to corrosion and high strength-to-weight ratio [2]. Earlier studies was reported on FSW method the effect of the

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process parameters on the joints has been studied; however there is a necessity to study the effect of microstructure on mechanical properties of Friction stir welded dissimilar Al alloys 5083 and 6061due to their heavy usage in marine, aerospace and nuclear applications. With this motive the research has been carried out to study the effect of process parameters on producing high strength dissimilar alloy joints.

EXPERIMENTATION

In this experimentation, base materials are Aluminum 5083 and Aluminum 6061 were used to fabricate the joints. Total of 8 joints were fabricated as per the design. The design parameters are in table 1, chemical compositions are in table 2, mechanical properties of base metal joint and fabricated joints are in table 3(a) and table 3(b).

Table 1 Design parameters

SAMPLE	Speed (rpm)	Feed(mm/min)	Tilt angle
S1	710	25	0º
S2	710	25	1º
S3	710	40	0º
S4	710	40	1º
S5	1120	25	0º
S6	1120	25	1º
S7	1120	40	0º
S8	1120	40	1º

Table 2 CHEMICAL COMPOSITIONS

AL 5083		AL 6061	
COMPONENT	Wt. %	COMPONENT	Wt. %
Al	92.4-95.6	Al	95.8-98.6
Cr	0.05-0.25	Cr	0.04-0.35
Cu	Max 0.1	Cu	0.15-0.4
Fe	Max 0.4	Fe	Max 0.7
Mg	4-4.9	Mg	0.8-1.2
Mn	0.4-1	Mn	Max 0.15
Other, each	Max 0.05	Other, each	Max 0.15
Other, total	Max 0.15	Other, total	Max 0.15
Si	Max 0.4	Si	0.4 to 0.8
Ti	Max 0.15	Ti	Max 0.15
Zn	Max o.25	Zn	Max 0.25

Table 3(a) MECHANICAL PROPERTIES OF BASE METAL PROPERTIES

Al 5083		Al 6061	
Yield strength	135	Yield strength	48
Ultimate tensile strength	280	Ultimate tensile strength	115
elongation	17	elongation	25
Impact		Impact	

Table 3(b) PROCESS PARAMETERS WELD METAL PROPERTIES

parameters	
Rotational speed (rpm)	1120
Traverse speed(mm/min)	25
Tilt angle	1º

Yield strength	105.804
Ultimate tensile strength	132.970
elongation	2.84
Impact	2

FIGURE 1 (A): Tool profile

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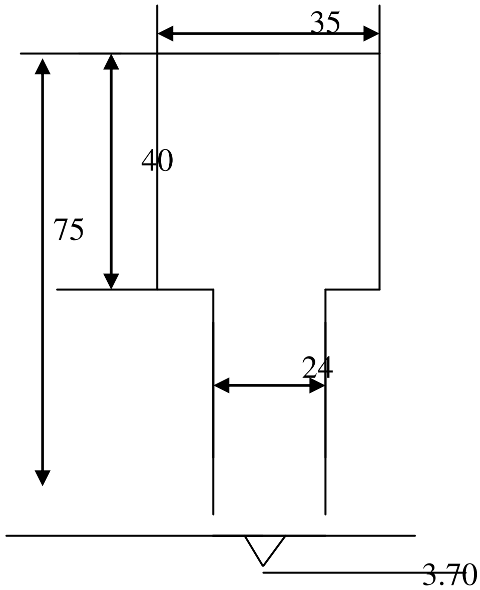

FIGURE 1(B): Tool geometry

FIGURE 2 Figure fabricated by FSW

The diagram of the plates from which the samples are cut is given in Figure 2 and the tensile test specimen is given in fig3A&B.

FIGURE 3 (A)

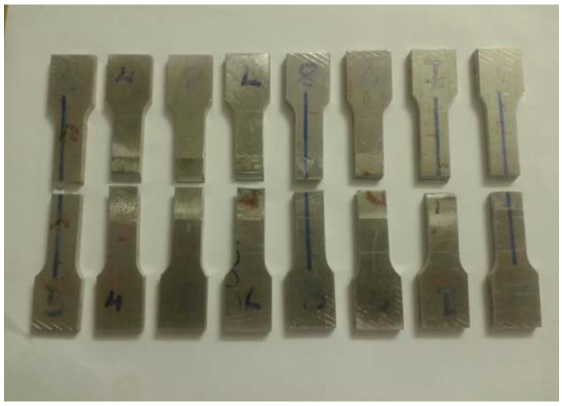

FIGURE 3(B)

SAMPLES FOR TENSILE TEST BEFORE AND AFTER TESTING

Mechanical properties:

S. NO	SPEED RPM	FEED Mm/Min	TOOL ANGLE	YIELD STRESS N/MM²	ULTIMATE STRESS N/MM²	% OF ELONGATION
1	710	25	0°	24.668	33.374	0.54
2	710	25	1°	34.549	44.768	0.66
3	710	40	0°	32.525	44.661	1.78
4	710	40	1°	42.397	56.212	1.74
5	1120	25	0°	49.709	65.406	0.42
6	1120	25	1°	105.804	132.970	2.84
7	1120	40	0°	31.531	49.208	0.68
8	1120	40	1°	25.138	35.573	0.74

RESULTS AND DISCUSSION

A. Visual assessment of welds

Fig. 3 display the macrostructures of the weld made by different friction stir tools and defect free welds are formed. From the visual

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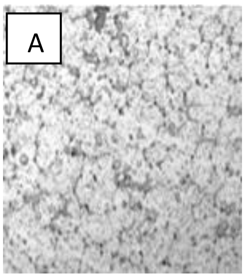
examination it was discerned that, the welds were formed with roots and crowns. The quality of the weld is defined by the material flow around the weld zone and it was deformed by the tool shoulder [3].

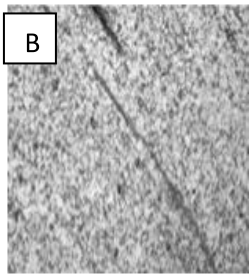
B. tensile properties

The tensile strength of the base metal alloy was measured and presented in (Table 2(a)). The tensile strength was observed at the stir zone welds at different tool rotation speeds i.e.710 r/min, 1120 r/min and welding speeds of 25 mm/min, 40 mm/min. By the fabrication of AA5083 and AA6061 metal joints, the highest ultimate strength is (132.97 MPa) exhibited at the rotational speed of 1120 rpm, feed of 25 mm/min and tool angle is 1^0 as compare to the base metal. The results of friction stir welded AA5083 and AA6061 aluminum alloy are shown in Table 3.

C. Weld microstructure:

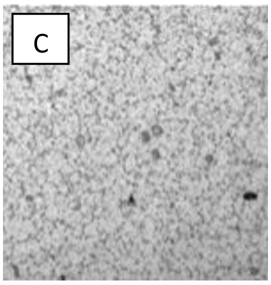
SPEED : 710 SPEED :
710
FEED : 25 FEED :
25 TOOL ANGLE: 0^0
TOOL ANGLE : 1^0

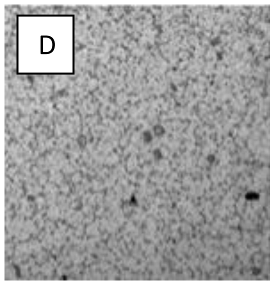




SPEED : 710
FEED : 40
TOOL ANGLE: 0^0

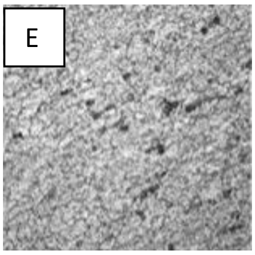
SPEED : 710
FEED : 40
TOOL ANGLE : 1^0

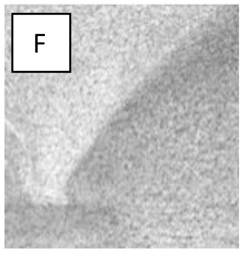




SPEED : 1120
FEED : 25
TOOL ANGLE: 0^0

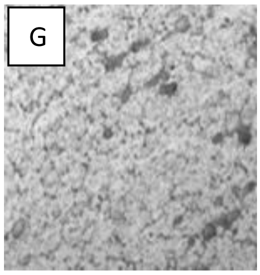
SPEED : 1120
FEED : 25
TOOL ANGLE: 1^0

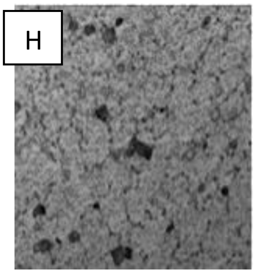




SPEED : 1120
FEED : 40
TOOL ANGLE: 0^0

SPEED : 1120
FEED : 40
TOOL ANGLE : 1^0





FIG(4) A,B,C,D,E,F,G,H ARE THE MICROSTRUCTURES OF FRICTION STIR WELDS

Optical microscopy evaluation was conducted to study the influence of the tool pin profile on microstructure of FSW welds. Fig. 4 shows the microstructure of the AA5083 and AA6061 weldments produced by tool pin profile at tool rotational speeds of 710rpm, 1120rpm, and weld speed is 40 mm/min, 20mm/min and tool tilt angle 0^0 and 1^0.

One of the important characters of the FSW is the different relative speed of plastic material on advanced side and on retreated side, which results in the different structures. On the advanced side, the speed grade is greater than on the retreated side, microstructure changes rapidly, lack of necessary transition, the zone between the nugget and the TMAZ often has the poor property, lack of necessary transition taken place by the lack of high temperature. In figure 4 (F) 1120rpm, 25mm/min, tool tilt angle 1^0 the weld region has experienced high temperatures and extensive plastic deformation and the size of the grain is very small, The parameters are given the fine micro structural properties.

CONCLUSION

The AA5083 and AA6061 alloys FSW process successfully obtained for different welding speeds, rotation speeds, tool angle and the tool profile. The influence of microstructure on mechanical properties of Friction stir welding of dissimilar Al alloys 5083 and 6061 was studied. It is observed that at rotation speed of 1120 rpm, & 25 mm/min tool angle 1^0 welding speed with conical profile resulted in good mechanical and microstructural properties.

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