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The Influence of Multi Pass Friction Stir Welding On the Micro Structural and Mechanical Properties of Dissimilar Aluminum Alloys

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ABRTRACT: *This paper investigates the influence of multi pass friction stir welding on the micro structural and mechanical properties of AA6082 and AA5083. Friction stir welding has already replaced conventional welding process in a variety of industrial applications especially in aluminum alloys. Friction stir welding is performed to join aluminum alloy 6xxx series with 5xxx. The concept of material flows during friction stir welding is yet not fully understood. Dissimilar metals like AA6082 and AA5083 alloys have been welded using this method. A wide range of pin profile and working conditions were used during this study. In particular, the effects of material's position and different pin profiles were studied on the parameters like material flow, tensile property, micro hardness and micro structure. It is observed from the microstructure that the material mixing is very effective when AA5083 alloy was placed in the advancing side. Three distinct zones with different extends of materials were identified and the formation mechanism of the three zones has been discussed.*

I. INTRODUCTION

In industries joining of metals is very important process. More welding process are used in industries now a days, like TIG,MIG etc., For joining non ferrous alloys and dissimilar metals are quite complicate in choosing the welding process. Now a day's friction stir welding is mostly used to join non ferrous metals and dissimilar metals. Friction stir welding (FSW) is an innovative process to join metals such as aluminum, magnesium, steel alloys and plastics in a solid state. It was invented by the Welding Institute (TWI) in 1991.The development of friction stir welding has provided a great opportunity for industry to utilize welding of high strength aluminium alloys. In this study AA 6082 and AA 5083 has been chosen and these materials are mostly used in ship industries were high strength is required. The reason for selecting the materials is that, the material should not get corroded when subjected to application.

II. EXPERIMENTAL SETUP AND METHODS

The schematic arrangements of the friction stir welding are shown in the Figure 1. The chemical composition of the alloys is listed in the table 1 and 2. AA5083 is kept at advancing side and AA 6082 is the retreating side with respect to tool direction. The methodology of this study is to vary the pin profile and number of passes while keeping the speed and feed rate as constant. Number of passes varied from one to three times. Also the combinations of different pin profiles used in multi pass welding. This methodology is depicted in table 3 and 4

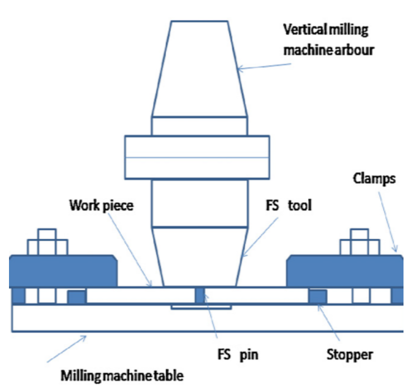

Figure 1 Schematic Arrangement of FSW Setup

Table 1 Chemical Compositions of AA5083

Si	Fe	Cu	Mn	Mg	Cr	Ni	Zn	Ti	Al
0.25	0.35	0.04	0.6	4.62	0.11	0.01	0.05	0.05	93.92

Table 2 Chemical Compositions of AA6082

Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Others	Al
0.9	0.4	0.08	0.49	0.7	0.05	0.04	0.02	0.02	97.3

Table 3 Experimental Methodology

Condition	pin profile	Material	Pass	Rotation (RPM)	Travel speed (mm/Min)
D1	Threaded pin	5083-6082	One	550	17.4
D2	Threaded pin	5083-6082	Two	550	17.4
D3	Threaded pin	5083-6082	Three	550	17.4

2.1 Friction Stir welding tool development

High Carbon High Chromium steel is chosen for this study. Chemical composition of HCHCR is 2% of carbon, 12% of chromium, silicon and manganese varies from 0.2 – 3.5%. Design of tool is a critical factor, since a good tool can improve the quality of weld and also the maximum possible welding speed. Shoulder diameter of the tool is 20 mm, pin of diameter 6 mm and length of 5.7 mm to weld the work piece of 6 mm thickness. The developed threaded pin profile tool as shown in figure 2

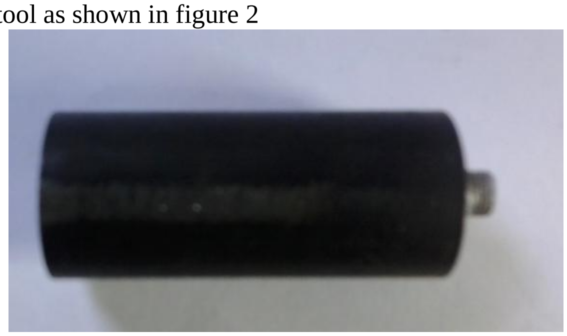

Figure 2 Threaded Pin Tool

2.2 Friction Stir welding fixture development

In friction stir welding clamping of the work piece is a critical factor. The fixture should be in the position to hold the work piece rigidly to ensure the weld quality. The fixture is chosen in this context and got fabricated. The fabricated fixture is shown in Figure 3 below

Figure 3 Friction Stir Welding Fixture

2.3 Experimental conditions

The following procedural steps are followed while doing FSW. The work piece of dimension of 100x75x6 mm and the edges preparation is done by milling machine. Before FSW, the flatness of the work piece was checked using dial gauge. The specimens are fixed in the as per the figure4 shown below.

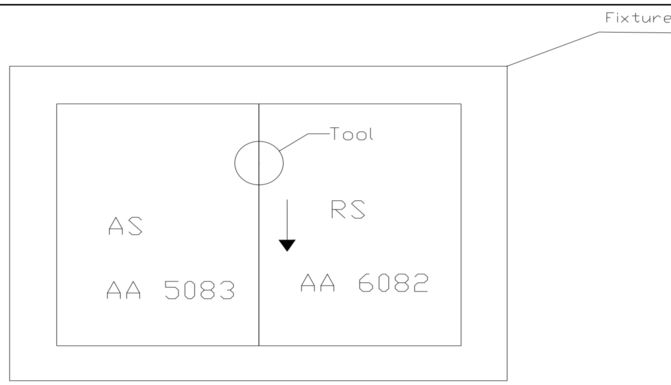

Figure 4 work piece arrangement

Spindle rotation was set at 550 rpm and feed rate of 17.4 mm/M in. Once, the tool is plunged into work piece, dwell period for 20 seconds was given to generate the heat and finally the longitudinal feed was given to complete the weld. For multi pass the tool is taken away from the work piece and restored back to the starting point and longitudinal feed is repeated till the weld is completed. Welded specimen is shown in Figure 5

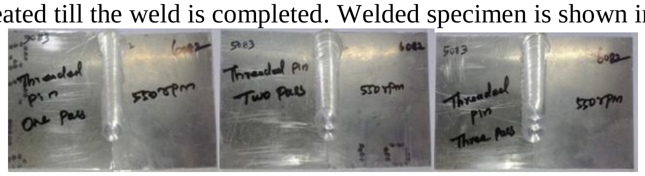

Figure 5 FSW specimens (a) One Pass (b) two Pass (c) Three Pass

III. MECHANICAL AND MICRO STRUCTURAL STUDY

3.1 Micro structural study

The welded samples were transversely sectioned and polished using conventional mechanical polishing methods. Micro-etching was carried out using keller's reagent for 20 – 150 s at ambient temperature to reveal the grain structures of the welds. Microstructural characterization was performed using an optical microscope. The sample specimen is observed as in figure 6

Figure 6 Microstructure Test Specimen

From the microstructure study it is observed that, the resultant joint has got fractured through hole. It is further observed that this is due to insufficient tool pin depth and clearance angle. The microstructure of the welded specimen as shown in figure7

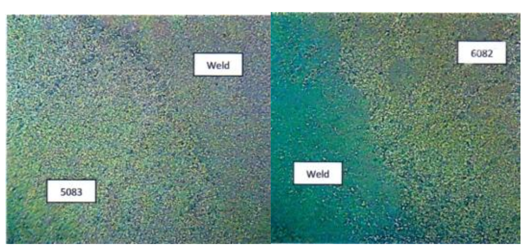

Figure 7 (a) Weld Interface between Weld zone and Base metal AA 5083 (b) Weld Interface between Welds Zone and Base Metal AA 6082

3.2 Mechanical study

The micro hardness value has got tested in either side of the welded region, heat affected zone and also in the base material. Observed hardness value has tabulated in Table

Table 4 Micro Hardness at Different Regions

Region	Weld	AA 5083 HAZ	AA 6082 HAZ	AA 5083 Base	AA 6082 Base
Hardness value (VHN)	**55.2, 61.6, 77.9, 70.5, 54.8**	**50.6, 48.4, 45.7**	**57.1, 62.3, 59.4**	**78.8, 89.8, 90.6**	**78.7, 86.7, 93**

Tensile strength of the welded specimen has to be tested as per the ASTM E-8 standard. The sample specimen has cut as shown in figure 8

Figure 8 Tensile Test Specimen

IV. RESULTS AND DISCUSSIONS

FSW Operation has been performed for dissimilar aluminium alloy for the threaded tool profile at constant feed rate. The number of passes varies from one, two and three passes. The micro structural and micro hardness has found for the one pass with threaded pin profile. From the micro hardenss value found from the one pass FSW specimen, in the welded region the micro hardness is varied from 50 to 80 VHN. Where as in the HAZ the value is less when compared to welded regions.

From the microstructure shows fusion between weld and base metals. The microstructure at AA 5083 base shows elongated particles of Al-Si and MgSi in a matrix of aluminium solid solution and at AA 6082 base shows elongated particles of Al – Si and Mgsi in a matrix of aluminium solid solution. Tensile strength and impact strength of one two and three pass welds has to be tested and, from the results the optimal parameters for defect free welding is to be suggested.

V. CONCLUSION

FSW operation has been performed for dissimilar aluminium alloy at 550 rpm and constant feed rate. Dissimilar aluminium alloys AA5083 and AA 6082 has been FSW successfully. The following conclusions were obtained from the results Defect free FSW joints were found The FSW welding zones like HAZ, Nugget and TMAZ zones were analyzed using optical microscope .From the microstructure study in AA 5083 having the elongated particles of Al-si Particles, in AA 6082 base having the elongated particles of Al-Si particles .Micro Vickers hardness test has been performed over the FSW region from the result it was found that the hardenss value at the welded region is almost 80% of the base material. But in the HAZ has the lower hardness value.

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