Friction Stir Welding Of AA5052& AA6061 Aluminium Alloy by using Taguchi method

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ABSTRACT - Aluminium alloys have gathered wide acceptance in the fabrication of light weight structures requiring a high strength to weight ratio and good corrosion resistance. In this study dissimilar welding of aluminium AA6061 and AA5052 6mm thickness plate were welded by friction stir butt joint using different Tilt angle (1°, 2°,) constant rotational speed (900 rpm) and transverse feed of (100 mm/min) at constant axial force 2KN. This shows that tool tilt angle, rotational speed, welding speed are the important parameters in deciding the ultimate tensile strength of the weld joint. The dissimilar joint was tested, micro hardness survey, and microstructure. This dissimilar friction stir welded butt joints are keeping AA 6061 plate on the advancing side and AA5052 plate on the retreating side.

An attempt was made to join the dissimilar aluminium plate of 6 mm thickness with conical threaded tool profile. The quality of the joint was evaluated by means of tensile strength, impact test, micro hardness, macro, microstructure and salt spary test.

Keywords: Friction stir welding, tool rotational speed, travel speed, tilt angle, Taguchi method

1. INTRODUCTION

Friction stir welding is a moderately new solid state joining process during this welding process, a special shaped FSW tool is rotated, plunged and then traversed along the joint to form weld. FSW has been used to weld the monolithic materials such as aluminum, magnesium, steel. Recently, several studies have reported that the FSW produces a high quality weld joint in aluminum based composites .The advantage of friction stir welding is it will eliminate all types fusion problem during welding.

The increasing demand for High strength weld in aerospace, automobile, and structural applications vast dissimilar applications are possible. These aluminum alloys are generally classified as non- weldable because of the poor solidification microstructure and porosity in the fusion zone. Also the loss in mechanical properties as compared to the base material is significant. FSW has many notable advantages over fusion welding in order to get good strength.

The proper choice of tool rotation and transverse speed will produce a good quality weld. The material use for base plate is Al alloy 5052 and AA6061 and the material use for the tool geometry is HSS.

It was observed all the pins preferred were broken due to high rotational speed and load applied. Pin profile has been changed to withstand the load. Design of Experiments is used to get a specific procedure for welding using the parameters used for welding.

This method (FSW) relies on the direct conversion of mechanical energy to thermal energy to create the weld with no application of heat from external sources. The rotational speed of the tools, welding speed, axial pressure, and the tool profile are the main principal variables that are to be controlled in order to provide the necessary combination of heat and pressure to form the weld. These parameters are adjusted so that the interface of joining metals is heated into the plastic temperature range (plastic state) where welding can take place.

The functional behavior of the welded joints was determined by the weld strength that is tensile strength, weld hardness and micro hardness. In this project an attempt will be made to determine and evaluate the influence of the process parameters of FSW on the welded joint.

Friction stir welding (FSW) is a developed solid state welding process to conquer the problems raised in fusion welding. This process uses a non-consumable tool. Rotational speed and frictional force generate heat. The welding parameters, such as tool pin profile, rotational speed, welding speed and axial force, play major role in determining the mechanical properties of welded joint.

Here Taguchi's method of design of experiments with 9 number of experiments and to get the results with good confidence limit. Taguchi's design of L9 orthogonal array was made for 3 levels and 3 factors. The factors selected are rotational speed, travel speed and tilt angle.

The specimens were then prepared for FSW welding. Further which need to take the tensile test to do the optimization using Taguchi`s method and characterization studies Tensile test were carried out across the FSW welded samples.

2. EXPERIMENTAL DETAILS

2.1 MATERIAL AND SAMPLE PREPARATION

From the given aluminum plate material was cut into the required dimension of 100X50X 6mm to get the required sample. As per the standards the chemical composition of AA5052 and AA6061 were given in Table 1 and Table 2.

Table -1: Chemical composition of AA6061 in weight%

AA6061	Mg	Si	Mn	Cr	Ti	Fe	Cu	Zn	others	Al
Comp%	0.8-1.2	0.4-0.8	0.15	0.04-0.35	0.15	0.7	0.15-0.4	0.25	0.15	Bal

Table -2: Chemical composition of AA5052 in weight%

AA5052	Mg	Si	Mn	Cr	Zn	Ti	Fe	Cu	Others	Al
Comp%	2.2-2.8	0.2 - 5	0.1	0.15 - 0.35	0.1	0.10	0.4	0.1	0.1	Bal

The Samples are welded by using HSS (High Speed Steel) then only we get required optimized sample from 9 samples.

Material and sample preparation

Table -3: Process Parameters

FACTORS	LEVEL 1	LEVEL 2	LEVEL 3
Rotational Speed (rpm)	700	900	1100
Travel Speed (mm/min)	70	90	110
Tilt Angle (0)	0	1	2

Experiments are performed to find the working levels of parameters. The levels are observed in experiments are shown inTable.3.It was chosen such a way that AA6061 in advancing side and AA5052 in retreating side so as to enhance corrosion behavior ofAA5052.

2.2 Design of Experiment

Taguchi`s designs aimed to allow greater understanding of variation than did many of the traditional designs. Taguchi contented that conventional sampling is in adequate here as there is no way of obtaining a random sample of future conditions. Taguchi proposed extending each experiment with an orthogonal array should simulate their and environment in which the experiment functions. ThedesignofexperimentisshowninTable.4

Table-4: Design of Experiment

Sample no	Tool Rotational speed (rpm)	Travel Speed (mm/min)	Tilt Angle (°)
1	700	70	0^o
2	700	90	1^o
3	700	110	2^o
4	900	70	1^o
5	900	90	2^o

6	900	110	0^o
7	1100	70	2^o
8	1100	90	0^o
9	1100	110	1^o

2.3 WELDED SAMPLES

Fig.1. Weld samples

2.4 Ultimate TensileStrength

Then tensile testing has been done on UTM until fractureofspecimenasperthestandardASTME8/E8M-09 and calculates the ultimate tensile strength and elongation for all specimens.

3. RESULTS AND DISCUSSION

3.1 ULTIMATE TENSILESTRENGTH

The table was showing the FSW AA 5052 and AA 6061 the value of ultimate tensile strength, percentage of

elongation, yield strength ,and also fracture location was observed for all specimens. They high tensile values of 209Mpa in optimized parameters on tool rotation 700rpm, travel speed 110mm/min, and tilt angle are 2º

Table -5: Tensile test results of dissimilar friction stir welded samples.

S.No	Yield Strength	UTS	% Elongation	Fracture location
1	105	140	5.20	Weld
2	98	122	6.70	Weld
3	174	211	10.50	Weld
4	65	112	9.80	HAZ
5	151	227	18.00	Weld
6	118	130	5.00	HAZ
7	103	132	5.60	Weld
8	65	80	6.00	Weld
9	144	166	7.00	Weld

Fig :2 tensile samples

3.2 Taguchi analysis:

They taguchi method are used optimization on parameter for friction stir welding are below mention the optimized parameter and plot graph on mean and SN/ratio shown.

Taguchi Design

Taguchi Orthogonal Array Design

L9(3**3)

Factors: 3

Runs: 9

Columns of L9(3**4) Array

1 2 3

Taguchi Analysis: UTS versus tool rotational speed, travel speed, tilt angle

The following terms cannot be estimated, and were removed.

tool rotational speed*travel speed

tool rotational speed*tilt angle

travel speed*tilt angle

Response Table for Signal to Noise Ratios

Larger is better tool rotational travel tilt

Level speed speed angle

1 43.71 42.11 41.09

2 43.46 42.30 42.37

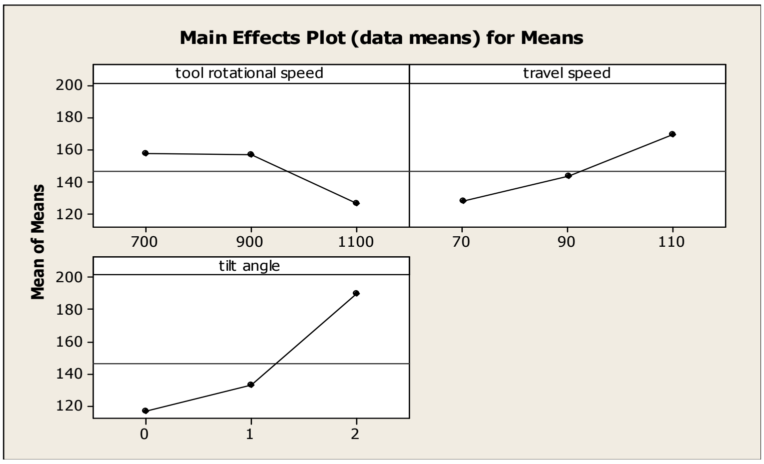
3 41.63 44.39 45.34

Delta 2.09 2.28 4.25

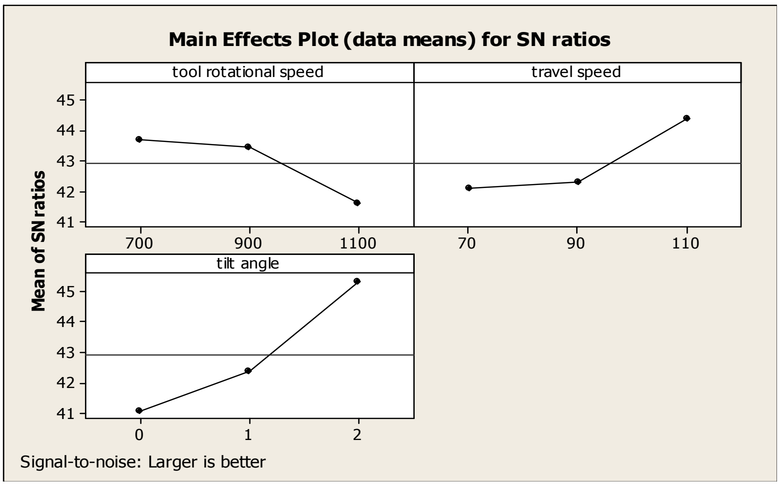
Rank 3 2 1

Response Table for Means

Level	tool rotational speed	travel speed	tilt angle
1	157.7	128.0	116.7
2	156.3	143.0	133.3
3	126.0	169.0	190.0
Delta	31.7	41.0	73.3
Rank	3	2	1



Main Effects Plot (data means) for Means



Main Effects Plot (data means) for SN ratios

3.1.1. Tilt Angle

The effect of tilt angle on the Tensile strength values are shown in fig.1 for taguchi method. So the optimum tilt angle is 2^0.

3.1.2 Rotational Speed

The effect of rotational speed on the tensile strength values are shown infig.1for taguchi method So the optimum rotational speed is 700rpm

3.1.3. Travel Speed

The effect of welding speed on the tensile strength values are shown in fig.1 for taguchi method .So the optimum travel speed is 110 mm/min

Disscussion

Taguchi method shows the variation of response using signal to noise ratio, so it can be resulted as minimization of experiments using uncontrollable parameter. The ultimate tensile strength was considered as the quality characteristic with the concept of "the larger is better"

The S/N ratio for the larger-the-better is: $S/N=-10*\log(\sum(1/Y^2)/n)$

Where is the number of measurement signal trial, in this case n=1 and is the measured value in a run. The S/N ratio values are calculated by take into consideration equation with the help of software Minitab15.

Finally we got the optimum value of parameters of welding process for maximum tensile strength which is given in the Table6

Table -6: Optimum Value of Parameter According to S/N Ratio

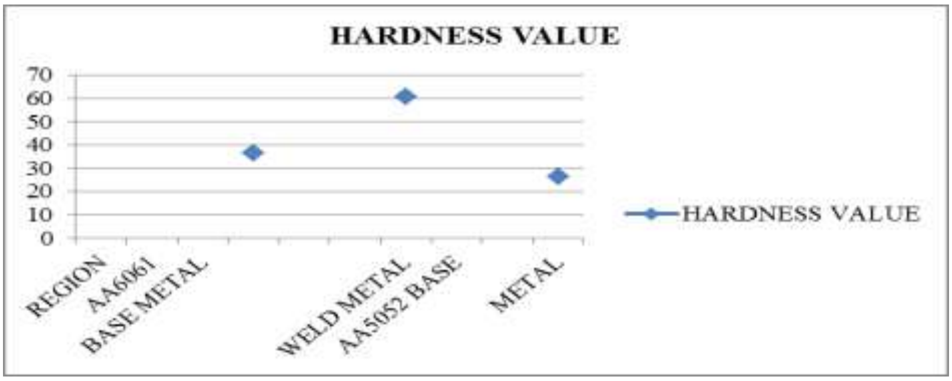
Tilt Angle	Tool rotational speed	Travel speed	UTS
2°	700	110	211

3.2 MICRO HARDNESS

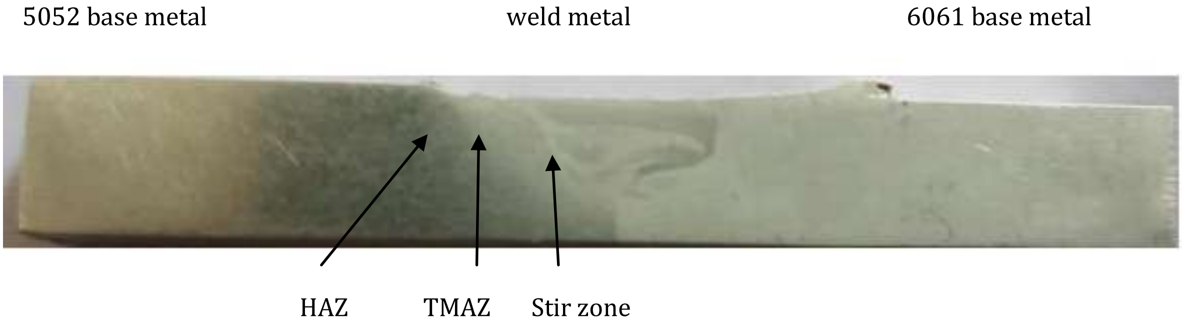
Micro hardness across the welded joint, have been carried out in polished and etched sections, as per the standard ASTM E 384-99. The hardness was carried out with Micro hardness tester using 0.5Kg weight for aluminium 6061-T6 and 5052-H111 with dwell time of 10s.

Table : 6 micro hardness in (HV)

REGION	HARDNESS VALUE
AA6061 BASE METAL	36.7
WELD METAL	60.7
AA5052 BASE METAL	26.3



3.3 Macro structure



After that the FSW welded specimen was etched with freshly prepared Keller's reagent of solution containing 190ml of water, 5ml HNO_3, 3mm HCL and 2ml HF to reveal the microstructures.

4. CONCLUSIONS

The study showed that dissimilar joints of Aluminium alloy 5052 and Aluminium alloy 6061 welded successfully by Friction Stir Welding Process to yield the required properties with out metallurgical difficulties. The following conclusions have been drawn from the study:

- The tensile strength of the dissimilar joints (AA5052&AA6061) was found. The higher tensile strength of 227MPa and it was observed that low rotational speed, lower travel speed, low tilt angle give more tensile strength.
- The optimum parameters are rotational speed of 700 rpm, welding speed of 110 mm/min and tilt angle 2degrees.
- These optimum parameters are used to test micro hardness.

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