Optimization of Process Parameters on Friction Stir Welding of AA2014 & AA6082 Aluminium Alloy

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Abstract - *The joining of the different materials to take advantages of the properties of each. Here AA6082 aluminum alloys butt welded with AA2014 to get high weldmetal properties and corrosion resistance. Both the alloys are Non-weldable because of the poor solidification and porosity in fusion zone. It is evident that the Friction stir welding is possible for dissimilar welding. To optimize the process parameters to get the better mechanical and microstructural properties of dissimilar joints AA2014 and AA6082 by friction stir welding using design of experiments in Taguchi`s method. The considered process parameters were welding speed, tool rotation speed, tilt angle. In this study the process parameters were optimized and ranked of parameters based on the Signal to Noise Ratio values and the optimized welding parameters were found the tool rotational speed of 1000rpm, Travel Speed of 70mm/min and Tilt angle of 2^0. An attempt was made to join the dissimilar aluminium plate of 6 mm thickness with conical tapered tool profile. The quality of the joint was evaluated by means of tensile strength and fracture surface analysis by SEM analysis.*

***Key Words*: Friction stir welding, tool rotational speed, welding speed, tilt angle, Taguchi method**

1.INTRODUCTION

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.

In plate form AA 6082 in T651, T6 & T4. The plate in T651 given heat Solution Heat treated and artificially aged. Material has high strength such as 7Mpa. The alloys AA2014 and AA6082 both in T6 Heat treated condition. 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. 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 and SEM analysis for optimized sample.

2. EXPERIMENTAL DETAILS

2.1 Material and sample preparation

From the given aluminum plate material a portion of material was cut into the required dimension of 25 X 25 mm (1 inch. X 1 inch.) to get the chemical analysis result. As per the standards the chemical composition of AA2014 and AA6082 were given in Table 1 and Table 2. Then the purity of the given material is checked by Spectroscopy technique.

Table -1: Chemical composition of AA2014 in weight %

Si%	Fe%	Cu%	Mn%	Mg%	Zn%	Ti%	Cr%	Al%
0.681	0.193	4.171	0.635	0.597	0.076	0.051	0.003	Bal.

Table -2: Chemical composition of AA6082 in weight %

Si%	Fe%	Cu%	Mn%	Mg%	Zn%	Ti%	Cr%	Al%
1.160	0.169	0.035	0.540	0.831	0.002	0.017	0.005	Bal.

The base material were cut into work samples of dimensions merely equal to 100 x 50 x 6 mm for the studies. They are being welded using conical tapered (HSS) pin profiles. Weldments of dimensions equals to 100x 100 x 6 mm were made by Friction stir welding.

2.2 Material and sample preparation

Table -3: Process Parameters

FACTORS	LEVEL 1	LEVEL 2	LEVEL 3
Rotational Speed (rpm)	800	1000	1200
Travel Speed (mm/min)	70	80	90
Tilt Angle (^{0})	1	2	0

Experiments are performed to find the working levels of parameters. The levels are observed in experiments are shown in Table.3. It was chosen such a way that AA6082 in advancing side and AA2014 in retreating side so as to enhance corrosion behavior of AA2014.

2.3 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 inadequate 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 the random environment in which the experiment functions. The design of experiment is shown in Table.4

Table -4: Design of Experiment

Sample no	Tilt Angle (⁰)	Rotational speed (rpm)	Travel Speed (mm/min)
1	1	800	70
2	1	1000	80
3	1	1200	90
4	2	800	80
5	2	1000	90
6	2	1200	70
7	0	800	90
8	0	1000	70
9	0	1200	80

2.4 Ultimate Tensile Strength

Then tensile testing has been done on UTM until fracture of specimen as per the standard ASTM E8/E8M-09 and calculates the ultimate tensile strength and elongation for all specimens.

2.5 Fractography Analysis

Scanning Electron Microscope is used for fractography analysis and microstructure evaluations at higher magnifications. Secondary electrons are used to tensile tested fracture surface for analysis in SEM.

3. RESULTS AND DISCUSSION

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

Sample no	Tilt Angle (°)	Rotational speed (rpm)	Travel Speed (mm/min)	Tensile Strength(Mpa)	Position of fracture
1	1	800	70	224	Base
2	1	1000	80	212	Weld
3	1	1200	90	223	Base
4	2	800	80	229	Base
5	2	1000	90	222	Weld
6	2	1200	70	230	Weld
7	0	800	90	161	Weld
8	0	1000	70	193	Weld
9	0	1200	80	147	Weld

The above table.5 shown that the ultimate tensile strength values of welded samples and its position of fracture of samples.

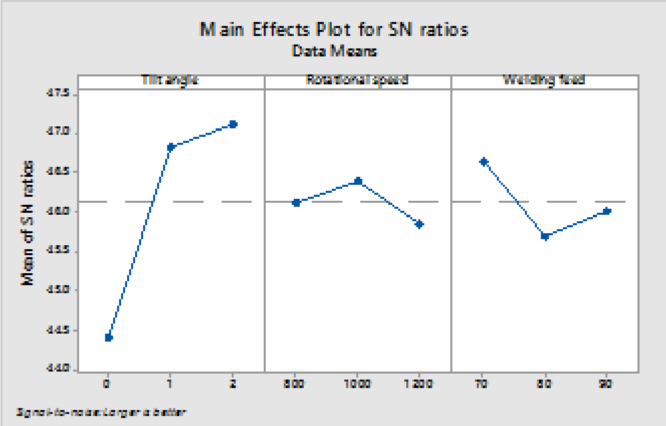

Fig -1: Effect of Welding parameters on Tensile strength for S/N Ratio

3.1.1. Tilt Angle

The effect of tilt angle on the Tensile strength values are shown in fig.1 for S/N ratio. It effect is increasing up to 2^0. So the optimum tilt angle is **level 2 i.e. 2^0**.

3.1.2 Rotational Speed

The effect of rotational speed on the tensile strength values are shown in fig.1 for S/N ratio. It effect is increasing up to 1000 rpm. So the optimum rotational speed is **level 2 i.e. 1000 rpm.**

3.1.3. Welding Speed

The effect of welding speed on the tensile strength values are shown in fig.1 for S/N ratio. It effect is increasing up to 70 mm/min. So the optimum welding speed is **level 1 i.e. 70 mm/min**.

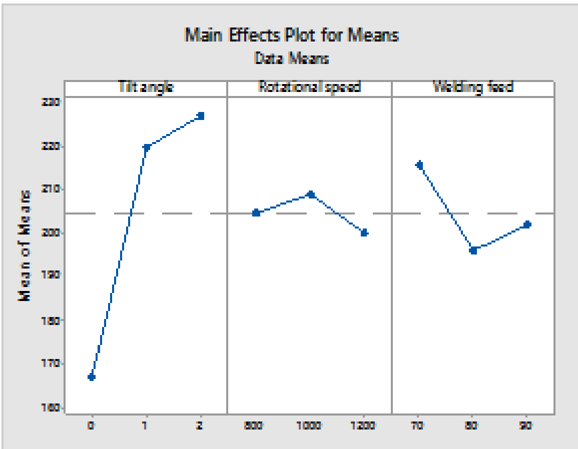

Fig -2: Effect of Welding parameters on Tensile strength for Means

3.2 Discussion

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 n is the number of measurements in a trial, in this case, n=1 and y is the measured value in a run. The S/N ratio values are calculated by taking into consideration equation with the help of software Minitab 15.

Finally we got the optimum value of parameters of welding process for maximum tensile strength which is given in the Table 6

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

Tilt Angle (°)	Rotational speed (rpm)	Travel Speed (mm/min)	Ultimate tensile strength (Mpa)
2	1000	70	254

3.3 Fracture Surface Analysis

The following fig 3 and fig 4 are the welded sample obtained from Fracture Surface analysis of the optimized parameter such as Tool Rotational Speed of 1000rpm,Travel Speed of 70mm/min and Tilt angle of 2^0. The fracture surface was examined in Scanning electron microscope at 500X, 1000X magnification, it was found that the fracture obtained ductile mode of fracture

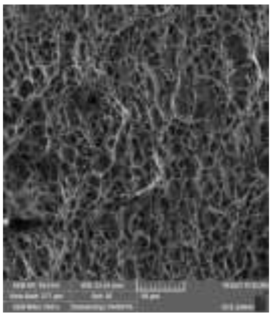

Fig -3: SEM image 1

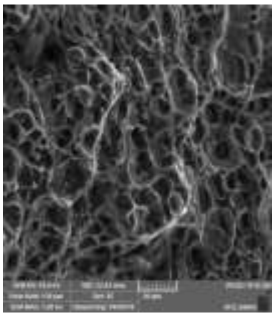

Fig -4: SEM image 2

4. CONCLUSIONS

The study showed that dissimilar joints of Aluminium alloy 2014 and Aluminium alloy 6082 welded successfully by Friction Stir Welding Process to yield the required properties without metallurgical difficulties. The following conclusions have been drawn from the study:

- The tensile strength of the dissimilar joints (AA2014 & AA6082) was found. The higher tensile strength of 254MPa and it was observed that higher rotational speed, lower welding speed, higher tilt angle give more tensile strength.
- The optimum parameters are rotational speed of 1000 rpm, welding speed of 70 mm/min and tilt angle 2 degrees.
- Taguchi results shown that most effective factor is tilt angle among all the considered factors. Other factors rotational speed, welding speed are ranked as 2, 3 respectively.
- SEM analysis shown that fracture was ductile mode of fracture.

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