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Research Article

Joint Analysis of Aluminium Alloys AA2014 welded to AA5052 by Friction stir welding using Taguchi method

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Abstract

Friction stir welding is a technique used to join materials which are difficult to weld, like Aluminium. It is solid state joining process used to join two workpieces together without actually melting the workpiece material. The tool is non-consumable and is rotating in between the workpieces facing each other. This tool is plunged into the joint area between the two different workpieces. The friction between tool and workpiece causes heat which further soften the region in workpiece near tool without reaching its melting point. This enables the tool to traverse along weld line. The soften and hot pieces of metal forged through close contact with tool shoulder and pin profile. The experiment was conducted to find the effect of different controllable parameters on the hardness of joint of 5mm AA2014 & AA5052 made by FSW. Brinell Hardness testing machine was used to test the hardness of the welding zone and base metal. Taguchi (MiniTAB 17) was used to optimize process parameters. High speed steel(H13) with shoulder 20mm, pin 6mm dia & 4.7 mm length was used as tool. Hardness test on 9 samples was performed & maximum hardness value of 79.9 HB was found on tool rotation speed 1950rpm, welding speed 50mm/min. & 2° tilt angle. Brinell hardness (HB) will measures the hardness by penetration depth indenter i.e. we have to punch an indentation on the surface of material. Experiment concludes that the hardness increases with increase in tilt angle. Hardness of joint was found satisfactory but lower than the base material AA2014.

Keywords: *FSW, Aluminium Alloy, Taguchi method, Hardness test*

1. Introduction

The Welding Institute established in 1968 at Cambridge (UK) patented a discovery in the category of solid state welding in 1991 called as Friction stir welding. As it is solid state welding, no melting of the workpiece takes place during welding process. A rotating tool is plunged into the workpiece, generate heat which causes the joining the joining of metals. The joining made by friction stir welding shows improved mechanical & metallurgical properties then conventional fusion welded joint. The translation & rotational movement of the non-consumable tool causes welding. In today world, demand of high strength to weight ratio increases which can be meet by aluminium. The materials used are AA2014 and AA5052 from 2XXX and 5XXX series respectively. AA2014 has copper as a major alloy element, which improves the strength and toughness of alloy and AA5052 has magnesium as major alloy element, which have moderately high strength, excellent corrosion resistance even in salt water, and very high toughness.

Y.M.Hwang *et al*. performed an experiment to check the hardness & tensile strength of FS welded copper butt joint, concluded that the hardness & tensile strength of the joint in about 60% & elongation increases to about 300% of the base metal.

Kush P. Mehta *et al*. investigated the effect of tool design on the mechanical properties of the friction stir welded Aluminium and copper concluded that using square pin , maximum hardness (283 HV) obtained.

D. Rao *et al* studied the mechanical properties of FS welded AA5083 and concluded that hardness profile changes rapidly in HAZ to SZ at advancing side as compared to retreated side

R.I. Rodriguez *et al*. performed friction stir welding on 6061 & 7050AA to evaluate that mechanical hardness & tensile strength increase with increase with in tool rotation speed.

2. Experimental Setup

In this study, 9 samples of dissimilar AA2014 & AA5052 is compared for the hardness properties. The sample of 100mm x 50mm x 5mm is prepared on milling machine. The FSW was done by using H13 as tool material with 20mm shoulder dia, 6mm tool tip dia., 4.7mm tool tip length as shown in fig.1 and three varying process parameters i.e. tool rotation speed, tool tilt angle & traverse speed. The different values are

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shown in table 3. Fixture with holding dimension as per workpiece was used to hold the workpiece rigidly. Semi-automatic vertical milling machine and Rockwell hardness testing machine was use to weld the workpiece and to check the hardness of the material.

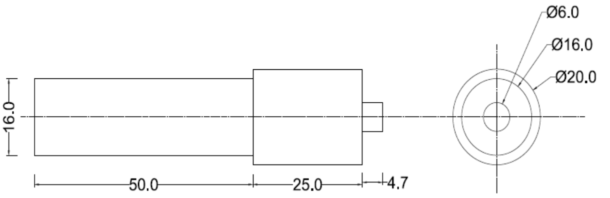


Fig.1 FSW welding Tool

Table 1 Chemical composition of material

	Si	Fe	Cu	Mn	Mg	Cr	Ti	Al
Al 2014	0.6	0.2	3.9	0.6	0.6	0.01	0.07	94
Al 5052	0.22	0.38	-	0.1	2.5	0.35	-	96.3

Table 2 Physical properties of Material

	Al 2014	Al 5052
Physical Propterties		
Density	2.82 g/cc	2.68 g/cc
Melting point	535°C	605°C
Thermal Expansion	23 x 10^{-6}/k	23.7 x 10^{-6}/k
Modulus of Elasticity	71GPa	70GPa
Thermal Conductivity	138 W/m.K	138 W/m.K
Electrical Resistivity	0.045 x 10^{-6} Ω.m	0.0495 x 10^{-6} Ω.m
Mechanical Properties		
Tensile Strength	440 Mpa	210-260 Mpa
Proof Stress	390 Mpa	Min 130 Mpa
Hardness Brinell	133 HB	61HB

3. Work piece preparation

The work piece are cut from plate by using power hacksaw and then prepared in accurate size of 100mm length, 50mm width & 5mm thickness (shown in fig. 2a,b) on milling machine, so that the matching surfaces are flat enough for accurate face to face contact

Fig. 2(a) Prepared workpiece

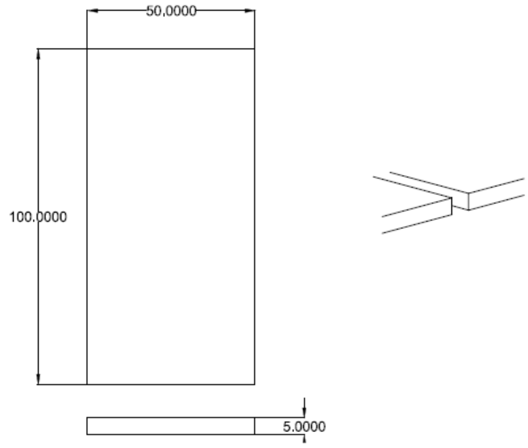


Fig. 2(b) workpiece sample with dimensions

AA5052 was put on advancing side & AA2014was at retreating side. The joint made after welding and position of penetration of nib ball on welded joint as well as on base metal is shown in fig 3

Fig. 3 Positions of penetration of nib ball on welded joints for testing hardness

Table 1 Parameter and variable used in process

Sr. no.	Rotational Speed(rpm)	Traverse Speed(mm/min.)	Tilt angle (degree)
1	1200	40	0
2	1200	50	1
3	1200	60	2
4	1950	40	1
5	1950	50	2
6	1950	60	0
7	3080	40	2
8	3080	50	0
9	3080	60	1

Table 2 Test Result and S/N ratio by taguchi methd

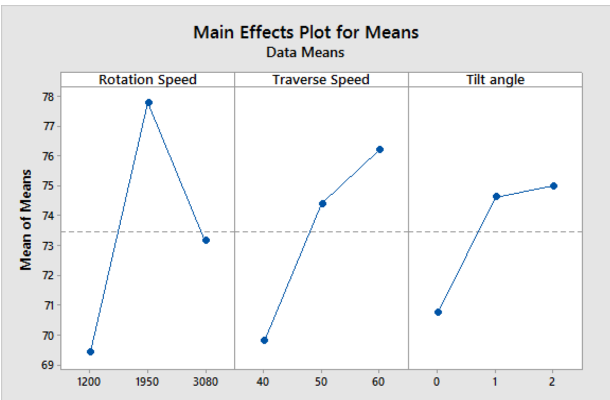
S. no.	Rot. Speed	Trav. Speed	Tilt angle	Test Res.	S/N Ratio	mean
1	1200	40	0	62.7	35.9454	62.7
2	1200	50	1	71.1	37.0374	71.1
3	1200	60	2	74.5	37.4431	74.5
4	1950	40	1	76.1	37.6277	76.1
5	1950	50	2	79.9	38.0509	79.9
6	1950	60	0	77.4	37.7748	77.4
7	3080	40	2	70.6	36.9761	70.6
8	3080	50	0	72.2	37.1707	72.2
9	3080	60	1	76.7	37.6959	76.7

4. Hardness Test

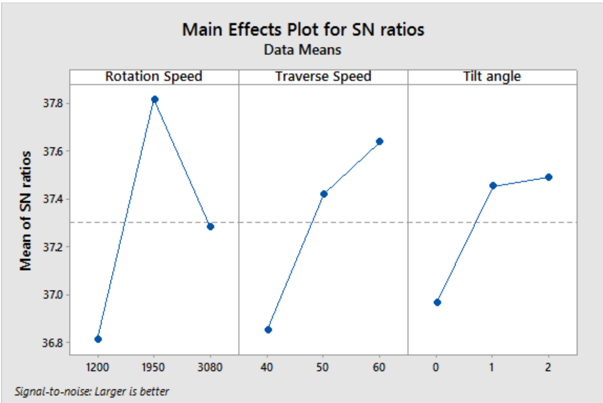
Hardness test was performed on rockwell cum brinell test machine with a High Speed Steel (HSS) ball of diameter 1/16 inch with a load of 100kgf is impacted on the surface of aluminium alloy welds and Rockwell hardness is measured on scale B. Three trials were performed on every work piece and mean of these trials was taken for end result. The results and graph given by taguchi method (minitab 17) after putting the result values is shown table 2 and in graph 1 and 2

5. Result

The maximum hardness was found at 1950 rpm tool rotation speed, 50 traverse speed, 2° tilt angle. The maximum hardness was found to be 79.9 HB and the minimum value was found at 1200 rpm tool rotation speed, 40 trverse speed, 0° tilt angle. The minimum hardness was found to be 62.7HB.



Graph 1: Mean for Hardness test



Graph 2: S/N ratio for Hardness test

Conclusion

1) Rotation Speed have maximum effect on hardness & tensile Strength among all process parameters.
2) With an increase in traverse speed and tilt angle hardness increases but with increase in rotation speed firstly hardness increases and then decreases.
3) Increase in tilt angle tensile strength increases but increases in rotation speed and traverse speed firstly tensile strength increases and then decreases.

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