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Research Article

Process parameters optimization of Friction stir welded AA5052-AA6082 using Taguchi method

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Abstract

In the present study, AA5052 is Friction stir welded with 6082 to find out the effect of process parameters on the hardness of the joint. The welding is performed on 5mm thick plates with one side single pass of H13 HSS tool. Parameters used in experiment are tool rotation speed(1200, 1950 & 3080rpm), welding speed(40, 50, 60mm/min.) and tool tilt angle(0, 1, 2°) with different combinations. Hardness test were performed on the 9 combination suggested by Taguchi method (miniTAB 17). The results shows that the maximum hardness was found on 1950 tool rotation speed, 50mm/min traverse speed and 2° tilt angle. The experiment also suggested that with increases in tool rotation speed and traverse speed, the hardness increase to a maximum level then decrease. The hardness found lower then both parent material.

Keywords: *FSW, Aluminium Alloy 5052 & 6082, Hardness.*

1. Introduction

Joining different materials having properties of both parent materials are very essential in today's world. Conventional welding has some difficulties in welding different materials like which material to be used as filler material etc. & if anyhow welded, the piece may have defects & decreased quality. To control all these complication of fusion welding, The Welding Institute (UK) proposed a welding technique names as friction stir welding. Friction Stir Welding setup consists of a Friction stir welding machine (it may be CNC milling or some automatic vertical milling), fixture & a tool. The tool used in FSW is non-consumable & consists of a shoulder & a pin. The work pieces are placed together & clamped rigidly in fixture, & rotating tool in plunged into the centerline of two pieces (rotation can be clockwise or counter clockwise) until the shoulder touches the surface of the work piece. The friction between work piece & tool generates heat. A zone of soften material is created around the nib/pin & just under the shoulder of the tool. The rotation of tool moves both materials towards each other & tends to mix the atom of both the plates. The forward movement of tool along centerline generates more heat & tool tends to move the material from one side to another which completes the welding

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2. Introduction to Material

Aluminium alloys are the alloys in which quantity of aluminium is more than other materials. Aluminium has a symbol Al and atomic no. 13. In the category of most abundant element metal, Aluminium gets 3rd position after O_2 & silicon. Aluminium 5052 have high strength & corrosion resistance as it have more quantity of magnesium (2.5%) but Aluminium 6082 have less cracking tendency and good weld ability as it have more quantity of silicon.

Table 1 Physical & Mechanical Properties

	Al 5052	Al 6082
Physical Propterties		
Density	2.68 g/cc	2.70 g/cc
Melting point	605°C	555°C
Thermal Expansion	23.7 x 10^{-6}/k	24 x 10^{-6}/k
Modulus of Elasticity	70GPa	70GPa
Thermal Conductivity	138 W/m.K	180 W/m.K
Electrical Resistivity	0.0495 x 10^{-6} Ω.m	0.038 x 10^{-6} Ω.m
Mechanical Properties		
Tensile Strength	210-260 Mpa	255 Mpa
Proof Stress	min. 130 Mpa	Min 300 Mpa
Hardness Brinell	61 HB	91HB

Table 2 Chemical Composition

	Si	Fe	Cu	Mn	Mg	Cr	Al
Al5052	0.22	0.38	-	0.10	2.5	0.35	96.25
Al6082	0.75	0.22	010	0.55	0.66	0.012	97

Table 3 Parameter and variable used in process

Sr. no.	Rotational Speed	Traverse Speed	Tilt angle
	(Factor 1)	(Factor 2)	(Factor 3)
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 4 Test result

Trail no.	Rotation Speed	Traverse Speed	Tilt angle	Hardness test
	Rpm	Rev/min.	Degree	HB
1	1200	40	0	33.4
2	1200	50	1	39.1
3	1200	60	2	38
4	1950	40	1	39.9
5	1950	50	2	42.9
6	1950	60	0	37.5
7	3080	40	2	39.4
8	3080	50	0	38.4
9	3080	60	1	40.3

3. Welding Variables

In friction stir welding two types of parameters are there, one is controllable which can be controlled or changed, second one is uncontrollable parameters which may have effect on welding but we cannot control them like temperature, vibrations, human error etc. Controllable parameters are welding speed, tool rotation speed, tool tilt angle, tool pin profile, downward force, shoulder & pin diameter etc. The parameters used in this experimental work are tool rotation speed, tool tilt angle & welding speed. The different values of the controllable parameters are shown in table 3 above.

4. Experimental Procedure

In this experiment 5mm sheet of aluminium alloy 5052 & aluminium alloy 6082 are used to join by Friction Stir Welding. For doing this H13 is used as material for welding with 20mm shoulder diameter, 6mm pin diameter & 4.7 mm pin length.

Firstly the pieces are cut at power hacksaw, and made in proper size with dimension as 100 x 50mm by using Milling machine. The tool with desired dimensions was prepared on lathe. Then the pieces are fixed in the fixture of semi automatic Milling machines. The rotating tool was then plunged into the workpiece till the shoulder touches the surface of work piece. After giving feed to the rotating tool along the centerline, the welding was completed. Hardness test was performed on the 9 samples suggested by Taguchi L9 orthogonal array. Hardness test was performed on Brinell hardness test machine with load capacity of 100kgf. Different values of process parameters & result of hardness test are shown in table 2

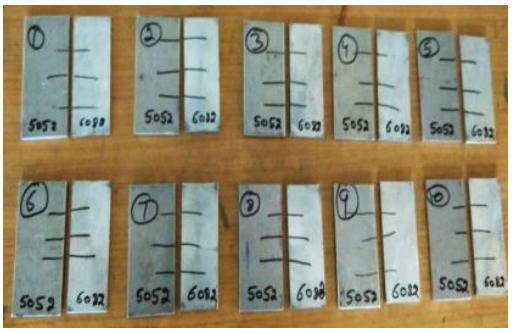
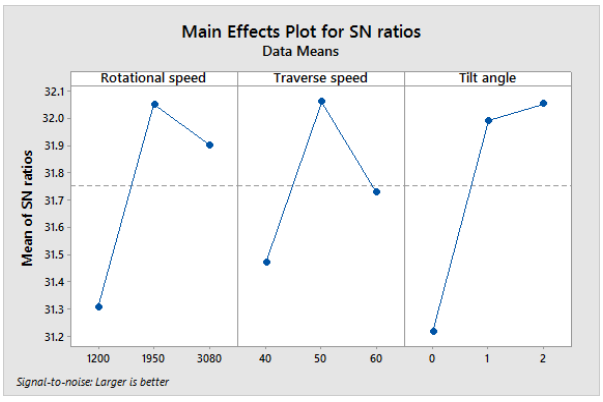


Fig 1 Workpiece sample

Fig 2 Friction stir welding tool (H13)

Fig 3 Friction stir welded pieces

5. Result & discussion



Graph: Plot for S/N ratio

In the present work hardness of the joint made by Friction Stir Welding has been evaluated. 9 experiments were performed by changing rotation speed, welding speed & tool tilt angle shown in table. The hardness test performed on sample gives values as shown in table 2. The maximum hardness value i.e 42.1 HB was found at 1950 rpm tool rotation speed, 50 mm/min traverse speed & 2° tool tilt angle. The plot shows hardness verses rotation speed, traverse speed & tool tilt angle graph.

Conclusion

- Welding done was found acceptable & no visible surface defects were found.
- At rotation speed 1950rpm, traverse speed 50mm/min. & 2° tool tilt angle, hardness was found maximum
- Increase in rotation speed and traverse speed causes increase in hardness upto a level. Further increase in both speeds will decrease hardness.
- Hardness was found 42.9HB i.e 61.55% of harder material i.e 6082 & 76.06% of lighter material i.e 5052.
- Tilt angle have maximum effect on Hardness.

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