A Study Of Process Parameters On FSW Of Aluminium Alloy (AA6063)

Deepak[1], Raj Kumar[2], Sunil Duhan[3]
[1]M.Tech. Student, Mechanical Engineering Department, Maharishi Dayanand University, Rohtak, Haryana, India
[2]Assistant Professor, Mechanical Engineering Department, Maharishi Dayanand University, Rohtak, Haryana, India
[3]Research Scholar, Mechanical Engineering Department, Maharishi Dayanand University, Rohtak, Haryana, India

ABSTRACT

Friction Stir Welding Process is a solid state joining technique which is used to joint similar and dissimilar metals. FSW is widely used for aerospace, marine, automotive and other applications. Compared to other conventional welding techniques friction stir welding (FSW) produces better weld zone with improved mechanical properties. The main objective of this article is to find the optimum parameters for joining of aluminum alloy 6063 plates in simple butt joint. The major factors taken for investigations are rotational speed, transverse speed and tilt angle of tool. The aim of this work is to determine the feasibility to weld two aluminum plates using FSW and to study the effect of process parameters on the mechanical properties of welding joints. Friction stir welding machine has been used for welding. The Mechanical properties of welded joints were investigated using different mechanical tests including tensile testing, percentage of elongation and hardness test. Sample with a maximum welding efficiency in terms of ultimate tensile strength was fabricated using 1400 (RPM) rotational speed, 55 (mm/min) transverse speed.

Keywords: Friction Stir Welding (FSW), Analysis Variance, AA6063, Aluminium Alloy.

INTRODUCTION

Friction stir welding (FSW) was invented at The Welding Institute (TWI) of UK in 1991 as a solid-state joining technique, and it was initially applied to aluminium alloys [Thomas et al. 1991]. FSW proves to be very promising in joining many ferrous and non-ferrous alloys that were joined by using conventional welding techniques with great difficulty. The convenience of the FSW technique has been demonstrated in a number of studies, especially for commercial purposes. A non-consumable rotating tool with a specially designed pin and shoulder is inserted into the abutting edges of sheets or plates to be joined and traversed along the line of joint. The heat input, the forging action and the stirring action of the tool induces a plastic flow in the material, forming a solid state weld [1].Due to the absence of melting of the metal, the FSW process is observed to offer several advantages over fusion welding. There four different micro structural zones observed in a FSW weld such as:

(i)Base Metal (BM)

(ii)Heat Affected Zone (HAZ)

(iii) Thermo mechanically affected Zone (TMAZ)

(iv) Nugget Zone (NZ) [2].

Normally high welding speed increases the tensile strength as compare to low welding speed as welded condition but it is reverse after post weld heat treatment and the welding process softens the material significantly which decrease the hardness, tensile strength and increases the ductility of the material [3]. In welding, the heat input plays an important role on the mechanical properties of the weld zone. The ultimate tensile strength increases with increase in weld speed in the tested range and decreases as tool rotational speed (TRS) increases. In FSW, it is understood that increasing the weld speed and decreasing the TRS, reduce the heat input required for joining leading to a reduction in the thickness of TMAZ and HAZ which, in turn, increases the tensile properties [4]. In addition to other defects, when tool feeds towards the part of plates which are in front of tool leave fixture surface and scroll around tool and rupture occurred. For this problem one can use clamps closely together also a roll which moves in front of tool and prevents sheets to go upward. Another problem is welding zone thinning that occurred in welding zone which cannot be prevented. In literature it is indicated that welding zone yield strength is 90% of parent metal [5]. To ensure a successful and efficient welding cycle the tool speed and tool geometry must be chosen with care, as both of these parameters are considerably important [6]. Raj Kumar in his study shows that Taguchi experimental design method determines the parameter setting whereas importance level of parameter on hardness, tensile strength, impact energy of Al6063 alloy can be resolute by ANOVA and S/N ratio [7].

2. EXPERIMENTAL PROCEDURE

2.1 Material

Aluminum 6063 alloy material is used for this investigation. The AA6063 Material was cut into 100 x 50 x 5 mm size plates. Chemical composition of AA6063 is listed in Table1.

Element	Si	Fe	Cu	Mn	Mg	Zn	Ci	Tr	Al
%	0.2-0.6	0.35	0.1	0.1	0.45-0.9	0.1	0.1	0.1	Bal

Table: 1

2.2 Friction Stir Welding Tool

Friction steel welding also depends on the tool profile. A proper tool results into the good welding finish. Tool profile includes the geometry of the tool and the material used to make tool. A non-consumable, rotating cylindrical tool made up of high carbon steel was used in this experimentation. Figure1 shows the tool profile:

2.3 Welding Parameters

For this study following parameters are mainly considered. They are

1. Transverse Speed (TS)

2. Rotational Speed (RS)

For FSW Process, the plates are placed in a butt configuration of 100 mm length; 50 mm width and the FSW process is carried out normal to the direction of the plates. The tool rotation is in the same direction of translation of the tool. First the two plates that should be welded kept in the bed and it is tightly fixed using the clamps in the bed. These clamps can hold the plates firmly even larger pressure or force is acted on it. The movement of the bed, rotation of the motor and the movement of the tool holder are done through the hydraulic devices and it is operated using the Control buttons which are present in the control panel in the FSW machine. The machine and assembly are shown in fig.2.

Figure: 2

Various specimens for determining the mechanical properties were prepared by using a wire cut EDM machine as shown in Figure 3

Figure: 3

3. RESULTS AND DISCESSION

In the present work, different FSW butt welds were obtained by varying the process parameters within the range and the optimal values are drawn based on the trend of the values. The weld joints are tested for tensile strength and hardness.

3.1 Tensile Test

The individual effects of the different parameters on the responses like tensile strength are studied and mathematical models are developed to foresee the effects of these parameters. MINITAB2017 software is used to optimize the parameters for the best response in the welding zone. It was find out that Ultimate tensile strength, yield strength and percentage of elongation all are dependent on the rotational speed, tool material, feed rate etc. parameters in the FSW process.

Sample no.	R.S(RPM)	T.S(MM/MIN)	% of elongation	UTS(KN/MM2)
1	1200	50	5.340	72.46
2	1200	55	7.980	77.10
3	1200	60	7.271	81.98
4	1350	50	6.161	67.35
5	1350	55	6.871	78.80
6	1350	60	7.071	81.76
7	1400	50	6.640	87.84
8	1400	55	8.180	107.65
9	1400	60	7.835	92.55

Table: 3 Tensile test results for various parameter samples

3.2. Hardness Test

Each mould sample is placed on the Vicker's Micro hardness machine and hardness test is done on three portions namely Parent metal, HAZ and nugget zone. Each plotted in the table 4.

Sample no.	R.S(RPM)	T.S(MM/MIN)	Hardness PM(HB)	HARDNESS TMAZ(HB)	Hardness HAZ(HB)
1	1200	50	70.9	48.8	63.5
2	1200	55	71.2	48.6	63.9
3	1200	60	71.4	47.3	64.5
4	1350	50	72.8	47.5	63.6

5	1350	55	71.6	48.1	64.7
6	1350	60	71.4	49.6	64.4
7	1400	50	71.8	47.7	62.5
8	1400	55	73.4	49.1	63.6
9	1400	60	72.7	48.5	63.8

3.4 Observations

Effect of tool speed on tensile strength At lesser rotational speed (1200 rpm), the tensile strength of FSW joints is lower. When the rotational speed is increased from 1200 rpm, melodiously the tensile strength reaches to a maximum at 1400. If the rotational speed is increased above 1400 rpm, the tensile strength of the joint decreased. Higher tool rotational speed (above 1400 rpm) resulting in higher heat input per unit length and slower cooling rate in the FSW zone causes excessive grain growth, which subsequently leads to lower tensile properties of the joints. Its effect is increasing with increase in tool speed up to1400 RPM. So the optimum tool speed is 1400 RPM.

Effect of feed rate on tensile strength Of the three welding speeds used to fabricate AA 6063 alloy joints, the joint fabricated at a welding speed of 55 mm/min yield good tensile strength. The joint fabricated at a welding speed of 55 mm/min exhibited higher tensile strength and this may be due to adequate heat generation that is exactly sufficient to cause the material to flow plastically with appropriate under condition. When the feed rate increases above the limit, then the tensile strength decreases because the avoidable grain evolution produces in welded region. Its effect is decreasing with increase in feed rate. So the optimum feed rate is 55mm/min.

Effect of feed rate and rotational speed on hardness It is observed from the test results done on various samples fabricated at various rotational and feed rates that the optimal values of the rotational speed and feed rate are 1400rpm and 55mm/min respectively at which the hardness is better. When the rotational speed and feed rate are increased or decreased from the optimal value then the hardness also decreases.

CONCLUSION

The butt joining of Aluminum alloy AA6063 was successfully carried out using FSW process. The samples were characterized by mechanical properties. The following conclusions were made from the present investigation.

• The optimum operating conditions of FSW have been obtained for two plates of aluminium alloy AA6063 welded in butt joint.

• A maximum mean ultimate stress exhibited by tool with optimal process parameters of tool rotational speed, 1400 rpm and transverse speed of 55mm/min.

• Rotational speed is the dominant parameter for equivalent stress developed on the tool followed by feed rate.

• It is found that percentage of elongation is less for all the specimens, which show the amount of heat generated in the process is less.

• Hardness of sample-8 is comparatively high in all zones of among the different sample. .

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