Investigation of Process Parameters on FSW of Aluminium Alloy (AA6061)

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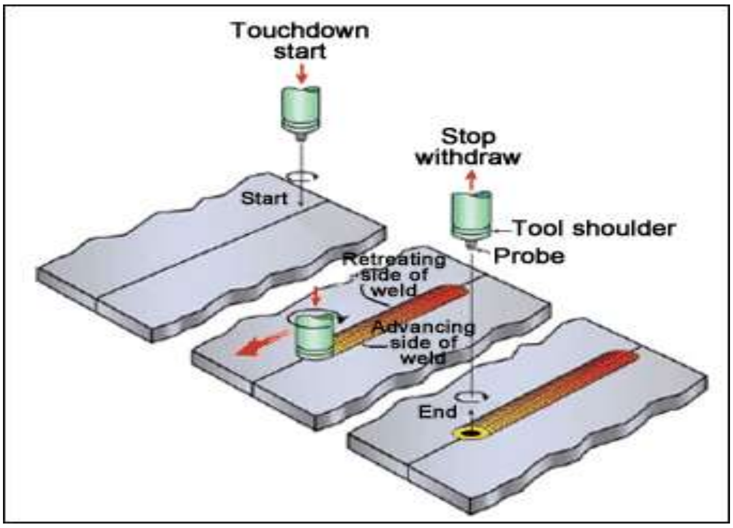
Abstract

Aluminium 6061 alloy is commonly used in the aircraft structures, such as wings and fuselages, more commonly in homebuilt aircraft than commercial or military aircraft. Aluminium 6061 alloy generally shows low weldability when welded using traditional fusion welding process. With development of Friction Stir Welding process (FSW) producing weld joint in aluminium 6061 alloys become very easy as compared to conventional processes. In FSW, the welding tool motion induces frictional heating and severe plastic deformation and metal joining process is done in solid state. A defect free weld with good mechanical properties in aluminium alloy 6061 can be obtained using FSW process. Unlike in traditional fusion welding, friction stir welds doesn't shows problems like porosity alloy segregation and hot cracking. Welds produced with good surface finish during FSW process. In this paper, an attempt was made to investigate the impact of process parameters of FSW on the mechanical properties of the weld zone. The tensile strength, microstructure, hardness of the FSW joints were investigated. The changes of mechanical properties are compared with the parental metal. The welding parameters such as tool rotational speed and welding speed plays a major role in deciding the joint characteristics. This paper focuses on optimization of all these parameters. From this investigation it was found that the joint made from the FSW yielded superior tensile properties and impact strength when tool rotational speed is 1200rpm and feed rate is 0.9mm/sec.

1. INTRODUCTION

Due to rise in usage of aircrafts, high steam boiler and automobile applications increases the demand of Aluminium alloy AA6061 which has magnificent mechanical and chemical properties. These are strength to weight ratio, ductility, cracking resistance and corrosion resistance in adverse climate conditions. Aluminium alloy is a soft material which causes porosity in welded region hot cracking and porosity could be dangerous (1). Thus, a different process is appointed to overcome this problem which was done by introducing solid state bonding. FSW (Friction Stir Welding) was introduced in 1991 by "The Welding Institute"(2). FSW is the process of welding which does not involve melting of metals then combined by casting instead it is done by brining two pieces in close contact then interface is forged together under the permanent plastic deformation by inserting rotating stir pin tool (3).



FSW uses a high speed rotating pin tool inserted inbetween the plates which are placed tightly with Butt Joint and proceed drilling until shoulder touches the surface of the plates provide smooth finished welded joint surface. Then move along the weld line with translation and rotatory motion within the spaces and the softened material which is in a state of heated before melting are forged at molecular level with permanent deformation. Rotating motion of the tool is in clockwise and translation is along the weld line are the important parameters (4).

2. LITERATURE REVIEW

Changes in microstructure formation of the welded joint by FSW were investigated by Cavaliere et all (5). He displayed the study FSW of different aluminium alloys plates AA2024 and AA7075.Whereas Munoz et al. (6) research showed the comparison between FSW and TIG welding of Al-Mg-Sc that mechanical and microstructural changes with the change in welding techniques. Muhsin et al (7) investigated the temperature variances occur during the FSW process and resultant is that temperature is a function of tool rotational speed and heating rate is a function of transverse motion of tool in the welded line.

There were several more parameters investigated like behaviour in material flow, microstructure formation and different mechanical properties welded depth, heat affected zone etc. Most effective parameters that can improve the quality of welded joint with strength and resistivity are the favourite topics for researchers (8-10).

FSW has a vast literature does describe the connection between mechanical properties and parameters of research. This research paper focuses on the optimisation of parameters ultimate tensile strength, % of elongation and tilt angle.

3. EXPERIMENTAL PROCEDURES

3.1 Material

AA 6061 aluminum alloy chemical composition and mechanical properties are shown in following table 1 and 2 respectively.

Element	Si	Fe	Cu	Mn	Mg	Zn	Cr	Ti	Al
%	0.62	0.33	0.28	0.06	0.9	0.2	0.17	0.02	Bal

Table: 1 chemical composition of Al 6061

Name of Al alloy	Yield strength in MPa	Ultimate strength in MPa	Elongation %	Hardness in HV
AA6061	110	207	16	75

Table: 2 mechanical properties of Al 6061

3.2 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.

3.3 Welding Process

For this study following parameters are mainly considered. They are

1. Transverse Speed (TS)
2. Rotational Speed (RS)

In this investigation a simple butt joint of rectangular plates of aluminium alloy was prepared through FSW process. The machine can rotate the tool at various speeds. In this investigation various speeds like 1000rpm 1200rpm 1300rpm 1350rpm etc was used. The transverse speed was 50 mm/min. The length of the tool pin is 4.5 mm. The mechanical clamps are used to clamp the plate. The plates of AA6061 aluminium alloy were machined to prepare the butt joint. Axial force is constant in this research work (11-13).

4. RESULTS AND OBSERVATIONS

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

After the welding done, the examples were cut into standard shapes for the further experimentations. Examples were cut into I-shapes for the tensile test, UYS, level of prolongation tests. Information gathered after the experimentation was considered further to see the impact of the different parameters on the weld joint. Results were given in the accompanying tables for different test tests.

SAMPLE NO.1	MEAN UTS	MEAN % ELONGATION
1	73.52	4.542
2	80	8.075
3	78.64	7.069
4	82.35	6.059

5	80.31	7.071
6	86.65	7.070
7	88.36	4.041
8	78.34	8.582
9	56.32	3.530

3.2 Hardness Test

The results of Hardness of Weld Zone (WZ), Parent Metal (PM) & Heat Affected Zone (HAZ) on different sets of combination of parameters were calculated according to the Brinell hardness (HB). The nine experiments were executed based on the L9 orthogonal array. The effect of various parameters on the weld zone such as tool rotational speed, translational feed and tilt angle was observed. The observational values of hardness and their S/N ratios and is shown in table 4.9

SAMPLE NO.	HARDNESS BM(HB)	HARDNESS TMAZ(HB)	HARDNESS HAZ(HB)
1	71.3	48.4	63.2
2	71.4	49.1	64.0
3	72.3	50.8	64.1
4	72.4	47.2	63.0
5	71.8	48.2	64.2
6	71.1	49.1	64.8
7	71.4	47.2	62.7
8	72.3	47.4	63.2
9	72.2	48.1	63.4

CONCLUSION

The butt joining of Aluminium alloy AA6061 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 AA6061 welded in butt joint.

• A maximum mean ultimate stress exhibited by tool with optimal process parameters of tool rotational speed, 1200 rpm and transverse speed of 0.9mm/sec.

• Rotational speed is the parameter which affects the weld joint mostly 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.

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