Effect of Weld Speed or Feed Rate and Rotational Speed on Two Dissimilar Metals Al-6063 and Al-7071 During Friction Stir Welding

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***Abstract*−**Friction stir welding (FSW) is a solid state welding process invented in 1991 by Wayne Thomas at The Welding Institute (TWI), Cambridge, United Kingdom. The process was initially developed for aluminium alloys, but since then FSW was found suitable for joining a large number of material. Since the last two decades it has been a subject of great deal of interest.

We studied about result and behavior of different material welded i.e. Al- 6063 and Al- 7071 by performing different-different test. In FSW parameters play an important role like tool design and material, tool rotational speed, welding speed and axial force. Hence the material was welded with the combination of different welding parameters i.e. tool rotation speed (2300 rpm,4600 rpm,3080 rpm) and the feed rate(30 mm/min, 20mm/min and 40 mm/min). It could be observed from the different tests (tensile, impact, and micro hardness test) performed that the maximum value of tensile strength and impact strength is 318.9 MPa and 27.3 joule respectively. The important benefits of FSW compared to fusion processes are low distortion, excellent mechanical properties in the weld zone, execution without a shielding gas, and suitability to weld all aluminium alloys.

Keywords:- *friction stir welding, 6063,dissimilar metals, tool rotation speed, feed rate.*

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I. Introduction

The ASM definition for a welding process is "a materials joining process which produces coalescence of materials by heating them to suitable temperatures with or without the application of pressure or by the application of pressure alone and with or without the use of filler material." [1]. One of the most recent and widely used solid state welding processes is friction stir welding process. It is used to join most aluminium alloys.Aluminium is light in weight and has good corrosion resistance & strength. Due to wide applications and advantages we have selected aluminium alloy for friction stir welding [2]. Friction stir welding (FSW) is a solid state welding process invented in 1991 by Wayne Thomas at The Welding Institute (TWI), Cambridge, United Kingdom. The process was initially developed for aluminium alloys, but since then FSW was found suitable for joining a large number of material.

Since the last two decades it has been a subject of great deal of interest. Friction stir welding is an emerging solid state joining process in which the material being welded does not melt and recast. Conventional fusion welding of aluminium alloys often produces a weld which suffers from defects such as porosity developed as a consequence of entrapped gas not being able to escape from the weld pool during solidification. In contrast, with FSW the interaction of a non-consumable tool rotating and traversing along a joint line creates a welding joint line through plastic deformation and consequent heat dissipation resulting in temperatures below the melting temperature of materials being joined. Other interesting benefits of FSW compared to fusion processes are low distortion, excellent mechanical properties in the weld zone, execution without a shielding gas, and suitability to weld all aluminium alloys.Prakash et al.,(2013) described a study of process parameters of friction stir welding of AA 6061 aluminium alloy. Conclusion have been made that tool rotation speed, tilt angle, weld speed & axial force are the main factor which effect welding. Silva et al.,(2013) described study of welding fsw (friction stir welding) of aluminium alloy 2024-t3 and electrolytic copper. Conclusion have been made that The efficiency of the welded joints is of the order of 0.45 compared to the base metal aluminum and 1.6 for copper,with significant loss of ductility. Eramah et al., (2014) described influence of friction stir welding parameters on properties of 2024 t3 aluminium alloy joints.

II. Experimental procedure

The materials under observation were Al 6063 and Al 7071 alloys plate of 5 mm thickness. 15 plates of size 150 mm x 50 mm were prepared. Plates were welded perpendicularly to the rolling direction. The employed tool rotation speeds of the cylindrical threaded tool were 2300 rpm, 4600rpm, and 3080 rpm with varying welding speed of 30 mm/min, 40mm/min and 20mm/min. A 17 mm tool shoulder diameter with shoulder height 20mm, pin diameter of 7 mm and 4.8 mm long was used. The welding tool is shown in fig 1.

Figure 1. Welding Tool

Tool profile use in this study was shown in fig 2. A cold-work tool High carbon, high chromium oil hardened type steel tool that comprises of outstanding high temperature strength, high temperature toughness, high temperature wear resistance and good machine ability is selected for present work.

For Friction stir welding process cut edges are finished with milling operation so that interfaces can be properly matched. The machine used for the production of the joints was semi-automated vertical milling machine. Fixture was fist fixed on the machine bed with help of clamps and then plates were held in the fiture properly for Friction Stir Welding. Aluminum plates of size 150 mm x 50 mm were prepared to obtain fie Friction Stir Welded joints at selected tool rotational speeds Specimens for the tensile strength analysis cut perpendicular to the weld line. Tensile test specimens were prepared from each weld in accordance with ASTM specifications, E-8M-08, having specimen of 50 mm gauge length and 12.5 mm width [1]. Tensile test was carried out at a constant speed of 2 mm/min at 16 kN load.

The load was applied until the necking was there and specimen failed, 20 specimens were prepared from welded joints and 2 specimens were prepared from base material for tensile testing.

Fig.2 CNC vertical milling machine

Tensile test specimens after tensile testing are shown in fig. 3. Visual inspection was performed on all welded samples in order to verify the presence of macroscopic external defects such as surface irregularities, excessive flesh, and lack of penetration, voids and surface open tunnel defects.

Fig.3. Specimen after FSW

The excessive fleshes and tunnel defects as shown in were absorbed at higher rotational speed of 3080rpm due to sufficient stirring and improper interaction of tool shoulder and work piece. It was observed in the visual inspection of the welded specimens that specimens welded with tool rotational speed 2300 rpm, welding speed 25 mm/min with tool shoulder diameter of 17 mm shows better surface texture as compare to other joints welded at other selected tool rotational speeds. This shows that at 4600 and 3080 rpm tool rotational speed, 60 mm/ min and 50mm/min. respectively welding speed along with 17 mm tool shoulder diameter was sufficient to join the plates with better surface textures.

III. Results & Conclusions

FSW has become a very effective tool in solving the joining problems of profiled, Where high ductility and tensile strength are required. In the present work, different FSW butt welds of Aluminium.

It is clear from the tensile test results and that welding with 2300 feed rate tool gives higher strength than 3080 feed rate tool welding and 4600 feed rate tool giver higher strength than 2300 feed rate. This is due to the additional compression of the tool shoulder which resulting in more heat .This additional compression of tilting the tool can remove any voids or tunnels resulting from the gap existing initially between the welded plates.

Figure 4.Specimen after tensile fracture.

The materials under observation were Al 6063 and Al 7071 alloys plate of 5 mm thickness. 15 sheets were successfully obtained by varying the processing parameters.

Table no.1 effect of feed rate

Sr. No	Nomenclature of sample	Feed Rate 30	Feed Rate 40	Feed Rate 50	AVG (HV)
1	2300 RPM SINGLE 'V'	27	28	30	28.33
2	4600 RPM SINGLE 'V'	28	29	29	28.66
3	3080 RPM SINGLE 'V'	26	27	29	27.33

Tensile Characteristics

Effect of tool rotation speed

It could be observed that the tensile strength decreases from 93 to 78 MPA with 30 tilted tool welding and 109 to 94 MPA with 40 tilted tool and 123 to 104 with 50 tilted tools. Increase in rotational speed from 2300 to 4600 rpm and keeping low welding speed and by increasing the tool rotational speed, there is sharp decrease in tensile strength. Ultimate tensile testing reading is shown in table 2.

Table no. 2 Effect of tool rotation speed

Sr.no	Feed Rate	Rotational speed (rpm)	UTS(N/mm^2)	% elongation
1	30	2300	93	9.23
2	30	2300	84	8.89
3	30	2300	78	8.39
4	40	4600	109	10.53
5	40	4600	98	9.56
6	40	4600	94	8.95
7	50	3080	123	12.47
8	50	3080	113	11.79
9	50	3080	104	10.68

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