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Investing Tensile Strength of Aluminium Alloy 6061 for Multi Line Friction Stir Lap Welding

Arpan mistry[1], Prof. kaushal bhavsar[2]
[1, 2]*Mechanical, Kadi University*

Abstract: Advancement of AL alloy has become more popular because of its specific application in aerospace and automotive industry. Fusion welding of AL alloys like 2xxxxx, 6xxxxx and 7xxxxx is difficult to perform. It has wide scope to weld Aluminium alloys using friction stir lap welding. Welded using cylindrical pin tool using two tool rotating speed of 710, 1400 rpm and at two different feed rates of 40 and 80 mm/min and its influence on tensile strength of Aluminium alloy 6061. Tool used for friction stir lap welding (FSLW) were made from high speed steel H13 with work hardening. Joint strength was evaluated by tensile test.
Keywords: Friction, Stir, Single, Double, Lap Welding

I. INTRODUCTION

Friction stir welding (FSW) is a solid-state joining process. It was invented at The Welding Institute (TWI) of UK in 1991 as a solid-state joining technique, and it was initially applied to aluminum alloys [1]. Lap joints are widely used in the assembly of parts and products in the transportation industry. Common examples include ship decks, railway tankers, goods wagons, and stringer to skin in aircraft Fuselages [1]. In friction stir lap welding (FSLW) tool rotating speed, welding speed and tool designee will have significant effect on the strength of welding. Friction stir welding (FSW) has been used to weld all wrought aluminum alloys, across the 2xxx, 6xxx, and 7xxx series of alloys[5]. Effect of friction-stir welding parameters on microstructure and mechanical properties of the dissimilar 430 stainless steel and 6061 aluminum alloy joints were investigated[6].

II. EXPREMENTAL WORK

In this research work we used aluminum alloy 6061 as a base material and its chemical composition is given in table 1. Rectangular aluminum plates of 90*30 mm were lap-welded by friction stir welding process. Thickness of base plate is 4mm. A vertical head milling machine was used for the experimental work which is located at work shop of LDRP. Fig 1 show experimental setup of friction stir lap welding. The lap joints were prepared for single lap and double lap. Tool used for friction stir lap welding is made from H13 material having conical pin profile. Dimension of conical pin used in this research are upper pin diameter is 2mm, lower pin diameter is 6mm and pin length used in this research is 6.2mm which is greater than thickness of upper plate. The welding parameters used in this investigation are given in table 2. Outline of single line and double line is shown in fig 2(a) and (b).

FIG – 1 EXPERIMENTAL SETUP

TABLE 1: CHEMICAL COMPOSITION OF 6061

Si	Mg	Cu	Fe	Mn	Ti	Zn	Cr	Al
0.75	0.9	0.5	0.5	0.15	0.05	0.03	0,03	Rest

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TABLE 2: THE USED WELDING PARAMETERS FOR SINGLE LAP AND DOUBLE LAP

Sr. No/exp no	Tool rotating speed (RPM)	Feed (mm/min)	Tensile strength (KN)
1	710	40	4.020
2	710	40	1.740
3	710	80	5.820
4	710	80	5.920
5	1400	40	4.060
6	1400	40	3.780
7	1400	80	1.640
8	1400	80	1.900

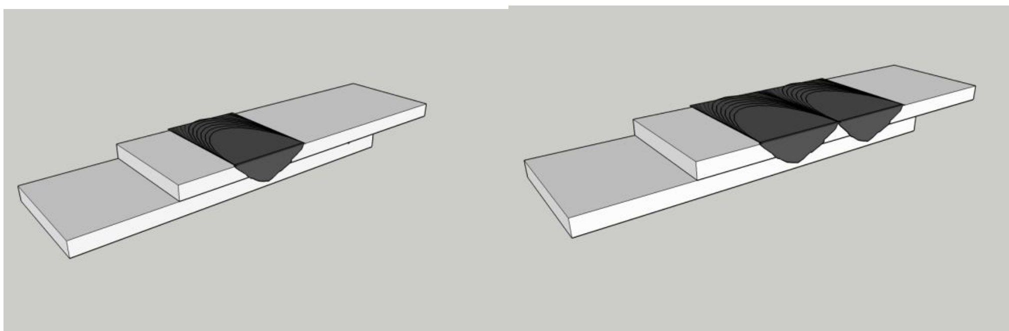

FIG 2A B
FIG 2(A) SINGLE LINE LAP JOINT, (B) DOUBLE LINE LAP JOINT

III.RESULT AND DISCUSSION

1) *Visual Inspection:* in this research work we used two feed (40,80)mm/min and two tool rotating speed(710,1400)RPM. From result we observed that at low feed and low tool rotating speed blank defect was not observed, but as we increase value of feed we observed blank defect on welded region. At low tool rotating speed smooth weld was obtained but with increase in tool rotating speed blank defect was observed on welded region. With maximum input condition feed 80mm/min and tool rotating speed 1400RPM we observed that high amount of blank defect obtain in both single line lap weld and double line lap weld.
2) *Tensile Test:* It has been found that the joint welded at a rotational speed of 710 rpm and welding speed of 80mm/s possess the highest failure load for both single line lap and double line lap as given table 4 sample 3 and 4. This result due to suitable balance between tool shoulder and base plate at tool rotating speed 710RPM and feed 80mm/min. Sample 7 and 8 in table 3 possess the lowest failure load where the joint produced under a rotational speed of 1400 rpm and feed of 80mm/min this is because high amount of blank defect was observed at this input condition.

Table 3: Tensile test results

Sr. No/exp no	Tool rotating speed (RPM)	Feed (mm/min)	No. Of lap	Tensile strength (KN)
1	710	40	1	4.02
2	710	40	2	1.74
3	710	80	1	5.82
4	710	80	2	5.92
5	1400	40	1	4.06
6	1400	40	2	3.78
7	1400	80	1	1.64
8	1400	80	2	1.65

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3) *Micro Structure:* Microstructure of 6061 aluminum alloy lap joint produced by friction stir welding and the base metal is studied by employing optical microscopy. In this study the microstructure of the stir zone(SZ), heat-affected zone (HAZ) and base material is shown in fig 3. Heat input during welding process controls the temperature of welding zone. The heat input during the welding process generally depends on the friction stir welding parameters. Heat input increased as value of rotational speed increased and is also proportional to contact area between shoulder face and the base material. As the rotational speed increases, the heat input during the friction stir welding process also increases. The evolution of microstructure in the stir zone (SZ) depends on the recrystallization temperature and the cooling rate of welding joint. The stir zone of welded lap plates was cooled by ambient air.

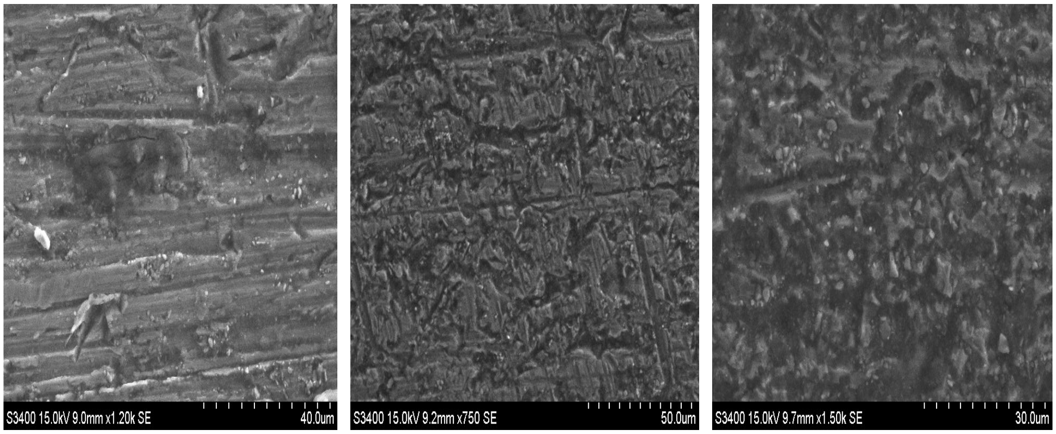

Fig 3(a) (b) (c)

Fig 3 (a) base material, (b) heat-affected zone (HAZ), (c) stir zone(SZ)

In this research work micro structure was performed on the optimum input condition are Tool rotating speed 710RPM and feed 80mm/min. From micro structure we observed that in base material, coarse microstructure is observed but as in heat-affected zone fine grain structure is obtained. Micro-structure of stir zone is have more fine grain structure as compare to heat-affected zone and this is because high amount of heat is generated in stir zone and metal matrix compotation is formed which result in fine grain structure.

IV. CONCLUSIONS

From result we conclude following conclusion:

- *A.* Lap weld of Aluminum alloy 6061 can be successfully welded.
- *B.* Changes in tensile strength are found minimal value for single line lap weld and double line lap weld joint.
- *C.* Double line lap weld is not more effective.
- *D.* In double line lap, when load is applied weld joint fails in one amongst two laps due to the line of grain separation.
- *E.* It can be concluded that tool rotating speed 710 RPM (Lower value) and Feed 80 mm/min (Higher value) give better strength.

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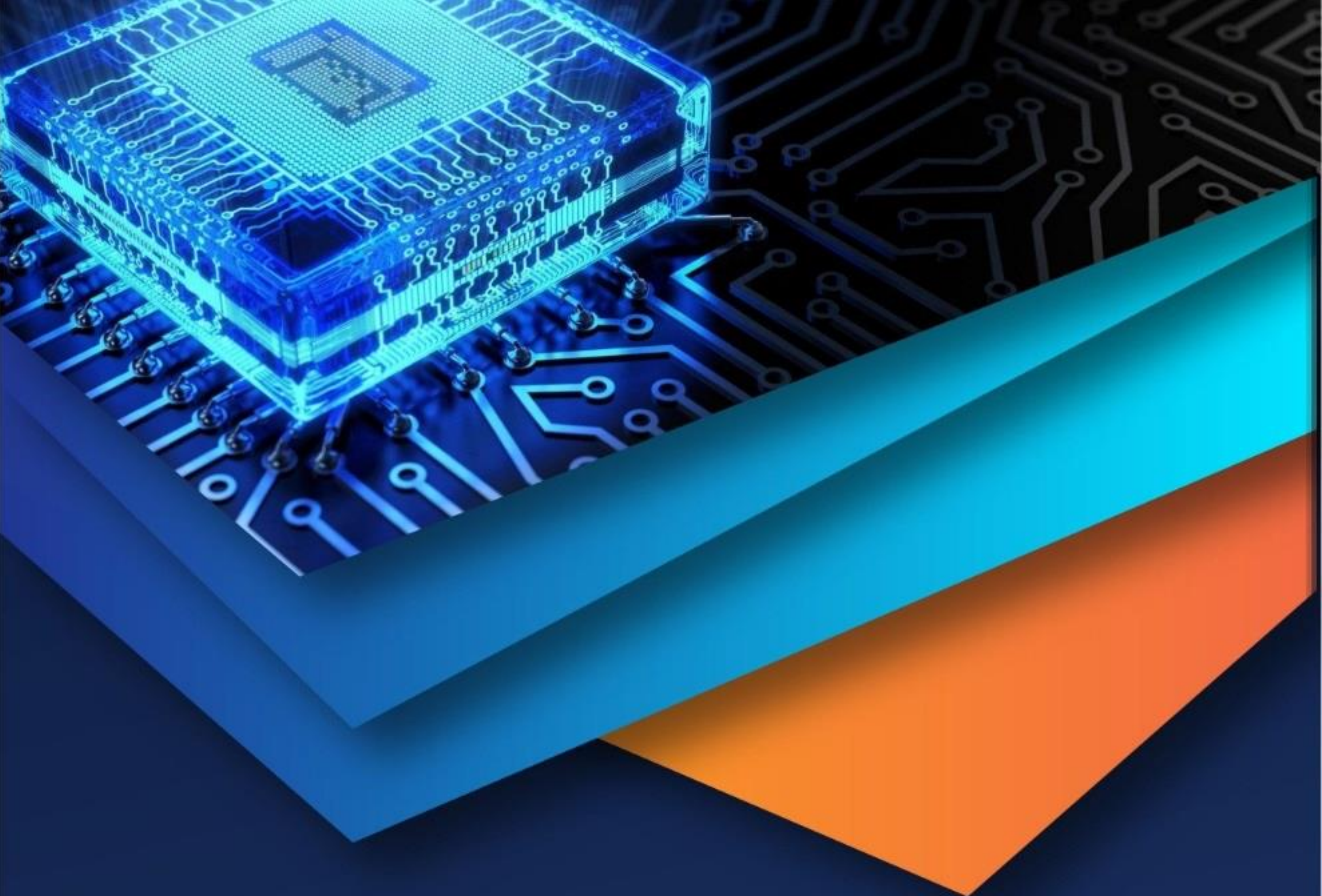

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