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Evaluation of Friction Stir Welded Lap Joint and Lap-Butt Joint of AA2024 and AA7075

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ABSTRACT: In this study focus on the lap joint and lap-butt joint of AA2024 and AA7075 alloy dissimilar materials of friction stir welding on mechanical properties evaluation were investigated. In present used the taper cylindrical tool pin and process parameters values under a constant load of 3 KN, tool rotational speed of 1000 rpm, the feed rate of 120mm/min, tilt angle 2°. It produced maximum tensile strength and yield strength of the lap-butt joint when compared to lap joint.

KEYWORDS: Friction stir welding of AA2024 and AA7075, Tool rotational speed, Mechanical properties.

I. INTRODUCTION

In friction stir welding (FSW) used as a solid-state joining process which produced no filler and no fumes. It economy environment is friendly as welding. FEW is used to join the several metals alloy of aluminium, copper, magnesium, zinc, steels, titanium. when metal is not melted due to friction heat produced of designed tool rotates on the base metal surface. The Main advantage of friction stir welding is without melting the base material it will be eliminating the welding defects of crack, porosity, spatter, undercut, over slag inclusion, in welding joints.

In this study about the dissimilar materials of AA2024 and AA7075 of microstructure and mechanical properties of lap and butt-lap welded joint. Due to friction heat is generated by tool and work material without reaching the melting point of base metal .when two material are leaves solid-phase bonded. It slightly decreased the high heat input, distortion and solidification defects. It showed the schematic diagram in Fig 1.

II. EXPERIMENTAL WORK

In these characteristics like good machinability, surface finish capabilities and mostly used in the automobile industry such as gears, shafts ,bolts, nuts crankshaft in aluminium 2024 and aluminium 7075 of parent material have properties such as tensile strength, yield strength, percentage elongation, hardness.

The friction stir welding of AA 2024 and AA7075 was performed by a semiautomatic FSW machine. Each plate having a 10mm length, 60 mm width and 6 mm thickness (100×60×6 mm) are prepared by machining, cutting, and milling process were considered and the chemical composition and mechanical properties of AA2024 and AA7075 alloy is shown in the table.

The machine has a load of 5 Kw and 10 hp motor and spindle speed of 1500rpm and feeds range from 120mm/min. And then machine has a travel distance 510 mm along the X-axis, Y-axis and, Z- axis 400 mm.

Table 1: Chemical composition of AA2024 alloy and AA7075

Aluminium alloys	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Al	Others
AA2024	0.50	0.50	3.8-4.9	0.3-0.9	1.2-1.8	0.10	0.25	0.15	balance	0.15
AA7075	0.4	0.5	1.2-2	0.3	2.1-2.9	0.18-0.28	5.1-6.1	0.20	balance	0.15

Table 2: Mechanical properties of aluminium alloy of AA2024 and AA7075

Alloy	Tensile strength(MPa)	Yield strength(MPa)	Percentage elongation
AA2024	490	380	11
AA7075	572	503	17



(a) AA7075



(b) AA7075

Fig 1: Base Metals

3.1 Tool material selection

Fiction stir welding a very important factor for tool material is being produced to the quality of welded joints. EN8 is a very popular grade of through hardening medium carbon steel which is readily machinable in any condition. EN8 is suitable for the manufacturing of parts such as general - purpose axles and shafts, gears, bolts, and studs. It can be further surface hardened typically to 50-55 HRC by induction processes, producing components with enhanced wear resistance. For such an application to use EN8. EN8 in its heat treated forms possess good homogenous metallurgical structure giving consistent machining properties. It details about EN8 tool steel heat treatment and chemical composition in tables 3 and 4.

Table 3: chemical composition of EN8 tool steel

EN8 material	% wt
C	0.36-0.44
Si	0.10-0.40
Mn	0.60-1
S	0.05 max
P	0.50 max

Table 4: Process Parameters

parameters	Observed values
Rotational speed (rpm)	1200
Travel speed(mm/min)	120
Tilt angle	2°

Table 5: Joint design

Lap joint	Joint design	
	T1	T2
	AA2024 and AA7075	AA7075 and AA2024
Lap-butt joint	T3	T4
	AA2024 and AA7075	AA7075 and AA2024

3.2 Welded Samples



(a) Lap jointed AA2024 and AA7075

(b) Lap jointed AA7075 and AA2024

Fig 2: Lap Jointed Welded Samples



(a) Lap-butt jointed AA2024 and AA7075

(b) Lap-butt jointed AA7075 and AA2024

Fig 3: Lap-butt Jointed Welded Samples

III. RESULTS AND DISCUSSION

A. Ultimate Tensile Strength

Then tensile testing has been done on the UTM machine as per the standard ASTM E8/E8M-09 and calculates the ultimate tensile strength, percentage of elongation, gauge width, gauge thickness, yield strength, and also fracture location for all specimens.

The tensile properties and fracture location of joints welded at lap and lap butt joint are given in tables 6 and 7.

Table 6: Tensile test for lap joint

Test parameters	Observed values for lap joint	
	T1 (2024 and 7075)	T2 (7075 and 2024)
Sample		
Gauge width (mm)	6.17	6.19
Gauge thickness (mm)	5.43	5.41
Original cross -section area (mm ²)	33.50	33.49
Ultimate tensile strength (N/mm ²)	2.16	1.97
Ultimate tensile load (kN)	65.00	59.00
Fracture location	Weld	Weld

In a lap joint, AA2024 was on the advancing side, AA7075 on the retreating side, T1 was formed. The maximum tensile strength of 65 Mpa is observed. The fracture was at weld metal.

In a lap joint, AA7075 was on the advancing side, AA2024 on the retreating side, T2 was formed. The tensile strength decreased to 59 Mpa was observed. The fracture was at weld metal.

Table 7: Tensile test for lap-butt joint

Test parameters	Observed values for lap-butt joint	
	T3(AA2024 and AA7075)	T4(AA7075 and AA2024)
Sample		
Gauge width (mm)	6.05	6.05
Gauge thickness (mm)	-	5.92
Original cross -section area (mm ²)	35.82	35.82
Ultimate tensile strength (N/mm ²)	77.00	78.00
Ultimate tensile load (KN)	2.75	2.80
Fracture location	weld	base

In a lap-butt joint, AA2024 was on the advancing side, AA7075 on the retreating side, T3 was formed. The tensile strength of 77 Mpa was observed. The fracture was at the weld metal

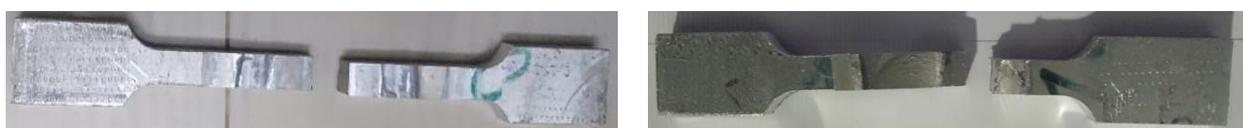
In a lap-butt joint, AA7075 was on the advancing side, AA2024 on the retreating side, T4 was formed. The tensile strength was increased by 78Mpa .The fracture was at base metal.



(a) Lap jointed AA2024 and AA7075

(b) Lap jointed AA7075 and AA2024

Fig 4: Lap jointed welded samples



(a) Lap-butt jointed AA2024 and AA7075

(b) Lap-butt jointed AA7075 and AA2024

Fig 5: Lap-butt jointed welded samples

B. Microhardness examination

Table 8: Hardness survey of lap joint (HV)

SAMPLES	BASE METAL	HAZ	TMAZ	STIR ZONE	TMAZ	HAZ	BASE METAL
T1	116.4	96.4	87.3	96.2	118.7	102.3	126
T2	113.2	92.2	80.4	100.2	104.8	101.2	122.9

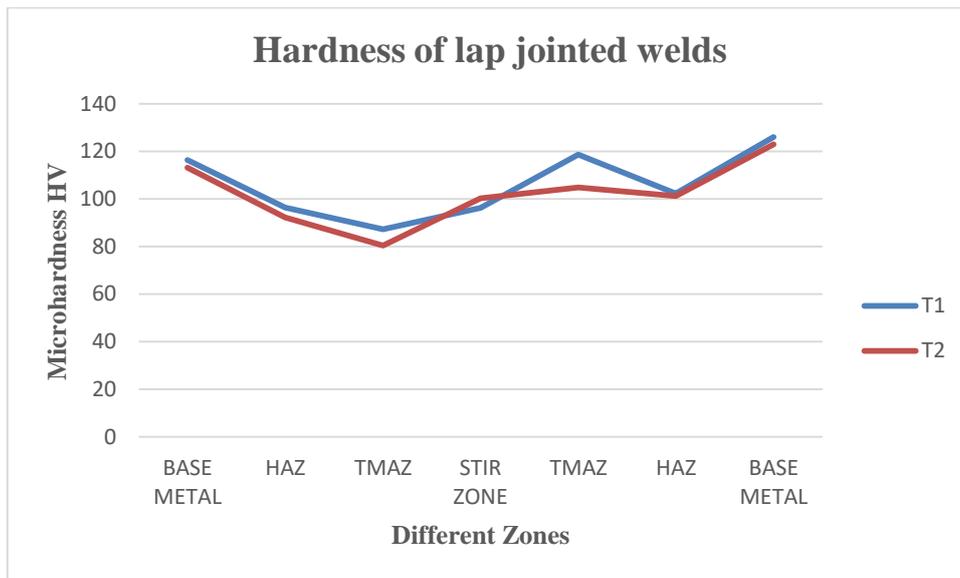


Fig 6: Microhardness of Lap Joints

The AA2024 and AA7075 (T1) lap joint, AA7075 and AA2024 (T2) are dissimilar weldments microhardness results are tabulated in Table 8. In the stir zone, 100.2 HV of high hardness of dissimilar AA2024 and AA7075 is similar to AA7075 and AA2024 joint was observed. The lower hardness of stir zone than the base metal and recrystallization in the stir zone during stir welding. So this leads to fine-grain than base metal in the stir zone which has increased hardness than HAZ.

Table 9: Hardness survey of lap-butt joint (HV)

SAMPLES	BASE METAL	HAZ	TMAZ	STIR ZONE	TMAZ	HAZ	BASE METAL
T3	126.2	102.6	115.5	90.2	80.4	90.2	112.3
T4	119	98.4	114.7	108.4	94.4	90.2	112.4

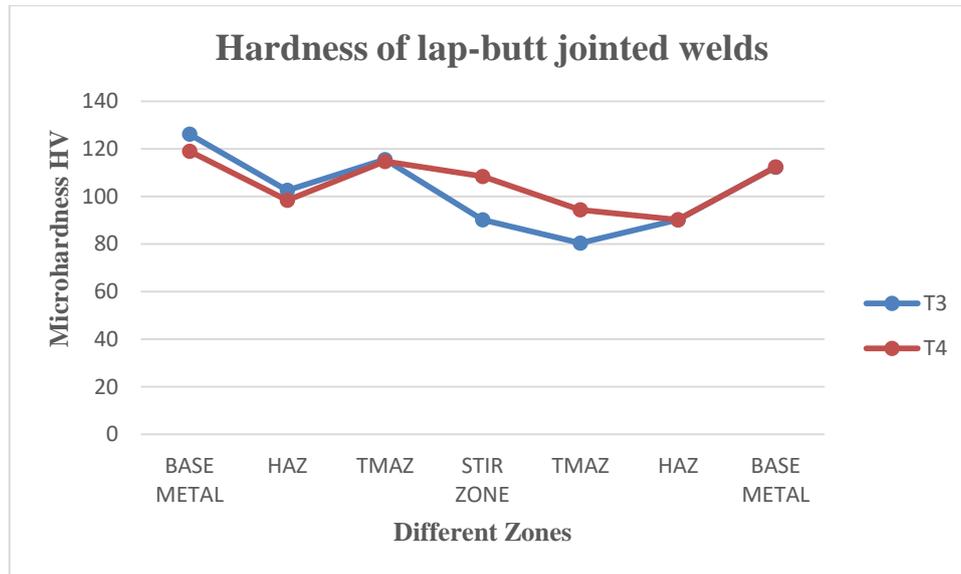


Fig 7: Graph of Microhardness of Lap-butt Jointed Welds

AA2024 and AA7075 (T3), AA7075 and AA2024 (T4) are dissimilar weldment of lap-butt friction stir welding microhardness results are given in Table 9. In the stir zone 108.4 HV of high hardness of dissimilar AA7075 and AA2024 (T4) to compared to AA2024 and AA7075 (T3), values are observed. The lower hardness of the stir zone than the dynamic recovery and recrystallization in the stir zone during stir welding. So this leads to fine -grain than base metal in the stir zone which in turn increased hardness than HAZ.

IV .CONCLUSION

The study showed that dissimilar joints of Aluminium alloy AA7075 and AA 2024 welded successfully by Friction Stir Welding of lap joint and lap-buttjoint. Some of the important observation of this study is as follows.

1. The higher tensile strength of 65MPa for the lap joint of AA2024 and AA7075(T1) when compared to AA7075 and AA2024 (T2). It gives more tensile strength for the lap joint of AA2024 and AA7075(T1)
2. The higher tensile strength of 78 Mpa for lap –butt joint of AA7075 and AA2024(T4) when compared to AA2024 and AA7075(T3) .It gives more tensile strength for lap- butt joint of AA7075 and AA2024(T4)
3. The optimum parameters such as the rotational speed of 1200rpm, welding speed of 120mm/min, and tilt angle 2degrees.

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