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Investigation on Welding Type on Friction Stir Welded AA2024-T3 and AA7075-T6 Dissimilar Aluminium Alloy: Effect of Welding Type- Single Stir and Double Stir

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ABSTRACT: Aluminium alloys play virtual role in aerospace industries due to high strength and fatigue resistance. The main application of aluminium alloys 2xxx series and 7xxx series in aircrafts- fuselage and wings. In the present work, dissimilar aluminium alloy (6mm thickness AA2024-T3 & AA7075-T6) joints were performed by friction stir welding to assess the influence of rotational speed, weld speed and plunge length on the microstructural features, material flow and mechanical properties of the joint. The friction stir weld sampling was done by using Tailor welded blank (TWB) method. Results indicated that the high microhardness were obtained from workpiece that was welded by single stir tool with AA2024-T3 on the advancing side and high ultimate tensile strength of 136MPa was obtained from the workpiece that was welded by single stir tool with AA2024-T3 on advancing side. The optimum welding parameters are plunge depth of 0.1mm, weld speed of 20mm per min, and spindle speed of 900 rpm with AA2024-T3 on advancing side and AA7075-T6 on retreating side.

KEYWORDS:FSW, Aluminium alloys, AA2024-T3, AA7075-T6, Tailor welded blank method, Microhardness and Ultimate tensile strength.

I. INTRODUCTION

Friction Stir Welding (FSW), a generally recently created welding method, has produced critical intrigue on account of the wide scope of favourable circumstances over the ordinary welding strategies. It is a strong state joining measure, where in the materials are welded without arriving at their dissolving temperature, utilizing frictional and adiabatic warmth produced by a pivoting and navigating barrel shaped device with a profiled pin. The frictional warmth produced by the welding device and the encompassing material causes the conditioning of the material and permits the device to be moved along the weld line. At first, the material is plasticized, and afterward it is moved from the main edge of the apparatus to following edge, leaving a strong stage connection between the plates. The benefits of this cycle likewise envelop better mechanical properties, low lingering pressure and disfigurement, and decreased event of deformities [1, 2]. The grating mix welded plates, have various districts over the width of the plates: the weld chunk, the Thermo-Mechanically Affected Zone (TMAZ) and the Heat Affected Zone (HAZ). The microstructure in the weld piece is commonly discovered to be fine and equi-axed, which upgrades the malleable property [2,3]. From the open literary works, it is gathered that the aluminium composites of 2xxx and 7xxx arrangement are not effectively weldable utilizing the ordinary methods. Electrical obstruction strategy is likewise used to weld scarcely any aluminium amalgams. Anyway these strategies require broad surface planning and counteraction of oxide development, which is very hard to acquire, and thus this restricts the utilization to explicit applications [4]. Likewise, the mechanical properties decline forcefully because of the arrangement of dendritic structure in the weld zone, when welded through

regular combination strategies [5]. On correlation with the customary welding measures like the Gas Metal Arc Welding (GMAW), the FSW strategy, offers numerous preferences. FSW is additionally condition neighbourly; likewise the vitality required in working the hardware just as subordinate gear, are generally less when contrasted and other combination welding procedures. What's more, since in FSW, the joining cycle is cultivated by material stream beneath the liquefying temperature, many joint deformities brought about by joint material dissolving, for example, porosity, grain limit splits and composites isolation can be significantly diminished. These cycle claims to fame have made FSW down to earth for joining different amalgams [6, 7]. The Tailor welded clear of AA2024-T3 and AA7075-T6 discovers its application in the car part just as the aviation businesses, where high solidarity to weight proportion is the most attractive trademark property. The FSW procedure is additionally being considered broadly as a swap for clasp, bolted and circular segment welded joining techniques [8, 9]. Besides, Tailor Weld Blank (TWB) of various blends of materials by different welding procedures is very testing. However, with FSW, fast and great welds can be accomplished.

II. EXPERIMENTAL PROCEDURE

The base materials employed in this study are 6mm thick plate of AA2024-T3 and AA7075-T6. The aluminium plates were cut into rectangular samples measuring 150 mm x 75 mm. The samples were longitudinally butt welded using a conventional vertical milling machine.



Figure 1: (a) FSW Process using conventional milling machine.



Figure 1: (b) Macrograph of the welded sample.

The welding process was carried out on the samples by keeping AA2024-T3 as advancing side and AA7075-T6 on the retreating side for single stir process. For the double stir process the samples keeping AA2024-T3 as retreating side and AA7075-T6 on the advancing side. The tool material used in this study was EN8 with heat treated tempered steel with a shoulder of 17 mm diameter along with 6 mm round of pin of length 4.5 mm. The process parameters were established based on the existing literatures as well as by trial and error basis. The welds were made with rotating speeds of 900 rpm and traverse speeds of 20 mm/min and the plunge depth of 0.1mm. Were the four trails made to obtain the optimum results the welding parameters are mentioned in the Table.1 For the microstructural

characterization, the welded samples were cross-sectioned perpendicularly to the welding direction. The specimens were prepared according to the standard metallographic procedure and were etched using Keller's reagent to reveal the microstructure. Transverse tensile studies were performed at room temperature, on the ASTM E8/8M standard samples using Universal Testing Machine. Hardness measurement was carried out on the composite region of the weldment using Vicker's Micro-hardness tester with 100gf load and dwell time period of 10s, at regular intervals of 0.25mm.

Table 1. Welding parameters:

Designation	Advancing side	Retreating side	Rotational speed (rpm)	Welding speed (mm/min)	Type of stir
Specimen A	2024-T3	7075-T6	900	20	DS
Specimen B	7075-T6	2024-T3	900	20	SS
Specimen C	2024-T3	7075-T6	900	20	SS
Specimen D	7075-T6	2024-T3	900	20	DS

III. RESULTS AND DISCUSSION**I. Microhardness testing:**

The micro hardness values are taken from various zones of the weldment i.e., Heat affected zone, Thermo mechanical affected zone, weld nugget and Stir zone.

The following table shows the microhardness value for the different zone.

Table 2. Microhardness value:

Specimen	Vicker's Hardness (VHN)							
	Advancing side				Retreating side			
	Stir	Nugget	HAZ	Stir	Stir	Nugget	HAZ	Stir
Single stir with 7075-T6 on advancing side	127.3	128	129.9	125	127.3	140	135.5	133
Double stir with 7075-T6 on advancing side	131.1	124	128.5	120.9	131.1	140.1	147.2	150.3
Single stir with 2024-T3 on advancing side	115	158	165	161	115	125	134.2	117
Double stir with 2024-T3 on advancing side	116.7	137.2	160.6	155.1	116.7	113.5	127	130



The following graph plots the Vicker’s hardness to the distance of the test from the centre of the weld for single stir welded joint with AA7075-T6 on the advancing side. It can be seen that the hardness value increases from the Nugget zone to the thermo mechanical affected zone and the fall on the both side.

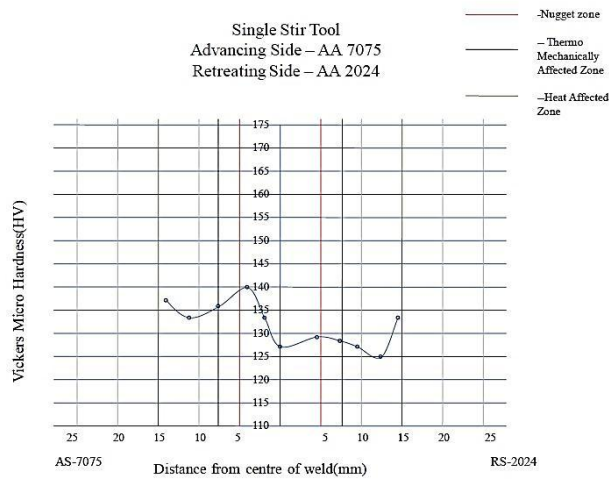


Figure 2: Micro hardness for single stir with AA7075-T6 on Advancing side

The following graph plots the Vickers hardness to the distance of the test from the centre of the weld for twin stir welded joint with AA 7075-T6 on advancing side. It can be seen that the hardness value increases from Nugget zone to Thermo Mechanical Affected Zone and then falls on the advancing side and also it decreases till the Nugget zone and then rises and falls at the Thermo Mechanical Affected Zone on the retreating side.

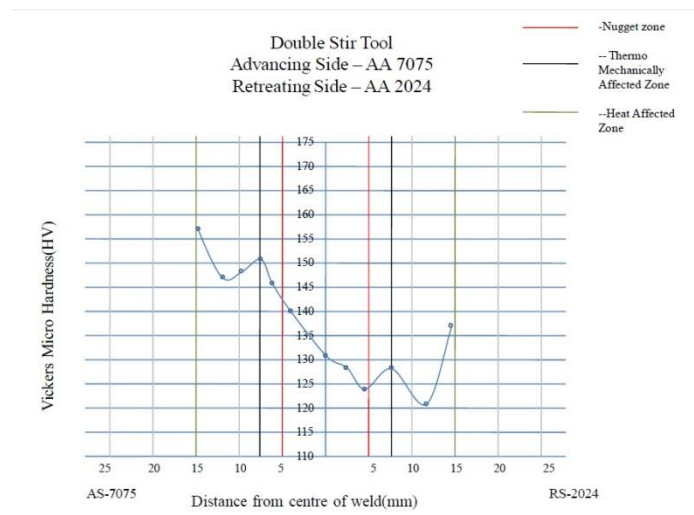


Figure 3: Micro hardness for Double stir with AA7075-T6 on Advancing side

The following graph plots the Vickers hardness to the distance of the test from the centre of the weld for single stir welded joint with AA 2024-T3 on advancing side. It can be seen that the hardness value increases from Nugget zone to Thermo Mechanical Affected Zone and then falls on both sides.

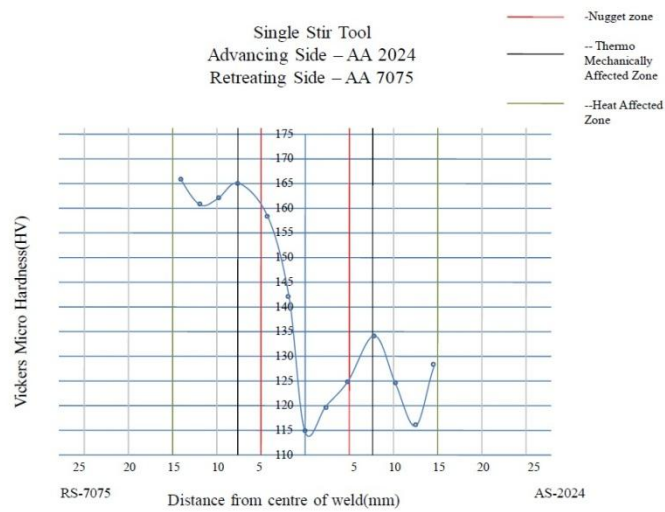


Figure 4: Micro hardness for single stir with AA2024 T3 on Advancing side

The following graph plots the Vickers hardness to the distance of the test from the centre of the weld for single stir welded joint with AA 2024-T3 on advancing side. It can be seen that the hardness value increases from Nugget zone to Thermo Mechanically Affected Zone and then falls on the retreating side and also it decreases till the Nugget zone and then rises and falls at the Thermo Mechanically Affected Zone on the advancing side.

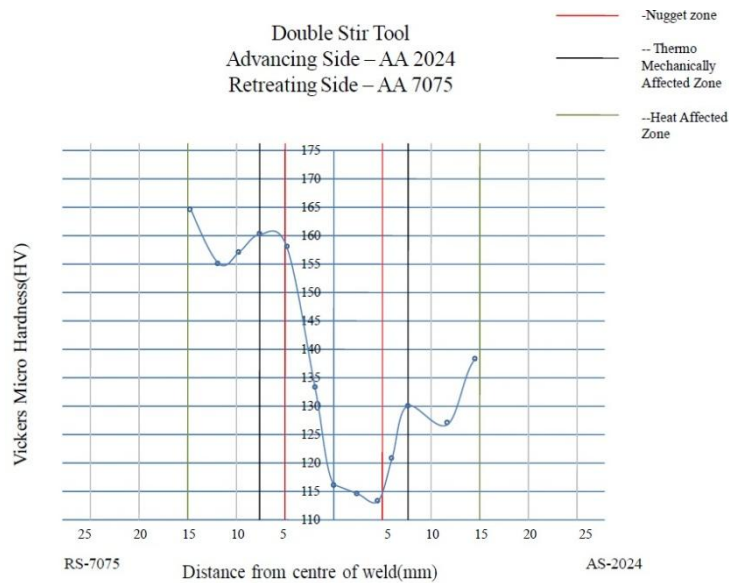


Figure 5: Micro hardness for double stir with AA2024-T3 on Advancing side

The following graph plots the Vickers hardness to the distance of the test from the centre of the weld for all the four specimens. It can be seen that the single stir welded joint with AA 2024-T3 on advancing side has the highest hardness.

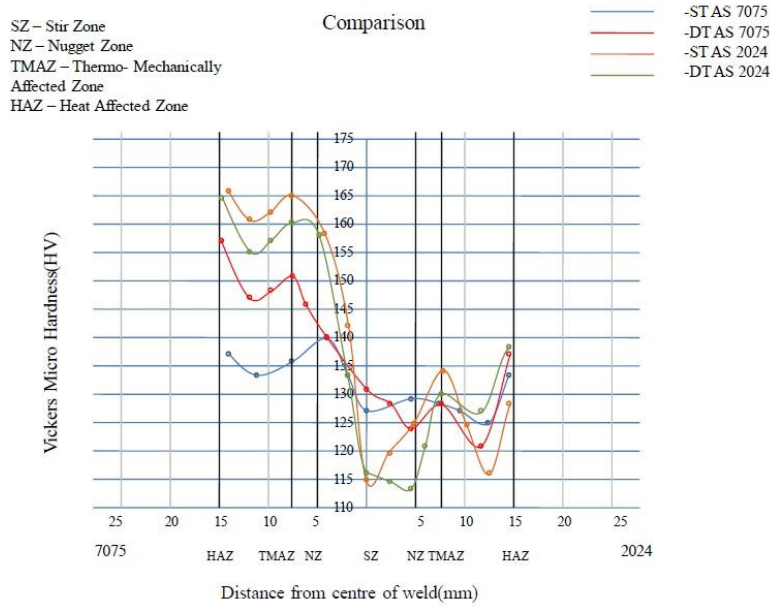


Figure 6: Micro hardness for four single stir with AA2024-T3 on Advancing side

II. Tensile testing:

The following table shows the ultimate tensile strength value at the stir zone for the different specimens.

Table 3. Ultimate tensile strength value:

Specimen	Ultimate tensile strength (MPa)
Single stir with AA7075 T6 on advancing side	125
Double stir with AA7075 T6 on advancing side	32
Single stir with AA2024 T3 on advancing side	136
Double stir with AA2024 T3 on advancing side	53

The following graph shows the tensile strength to the speed of the tool rotates. The optimum speed is 900rpm so, the graph is drawn to show how the tensile strength different specimens. It is noted that, the single stir welds shows the highest tensile strength then the double stir.

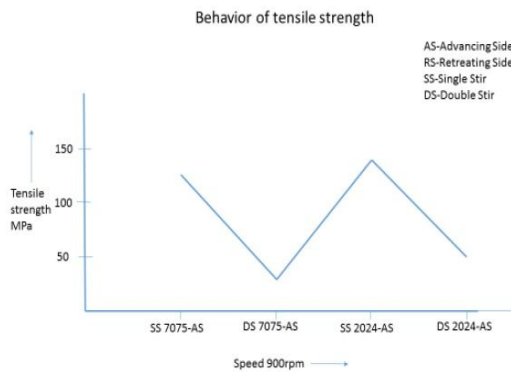


Figure 7: Line chart for Ultimate tensile strength

- ❖ Welds made with single stir show higher value of hardness, compare to twin stir. Formation of defect-free weld is a function of both the rotational speed and the welding speed.
- ❖ From the micro hardness comparison graph of the four different workpieces, it can be concluded that the workpiece that was welded by single stir tool with AA 2024 on the advancing side has the highest micro hardness.
- ❖ From the ultimate strength comparison table of the four different workpieces, it can be concluded that the workpiece that was welded by single stir tool with AA 2024 on the advancing side has the highest ultimate strength of 136 MPa.
- ❖ Thus it can be concluded that the workpiece welded by single stir tool with AA 2024 on advancing side shows the best properties when welded by Friction Stir Welding.

The Optimum welding parameters are plunge depth of 0.1 mm, weld speed of 20 mm/min, spindle speed of 900 rpm and with 2024-T3 on advancing side and 7075-T6 on retreating side.

IV. CONCLUSIONS

- a) The welding experiments of FSW butt joint for dissimilar aluminium alloys AA 2024 and AA7075 plates were performed using various welding parameters and effects of welding parameters on the property of FSW welds were investigated.
- b) At 900 rpm welds were made with single stir shows better hardness profile than twin stir. Micro Vickers hardness test has been performed over the FSW region, from the result, it was found that the hardness value is better in single stir weld than the twin stir.
- c) Also the advancing side and retreating sides are influencing the result. Weld made with AA2024 as advancing side shows the better hardness and strength compared to weld made with AA7075.

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