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Effect of process parameters on AA 7108 T79 using friction stir welding on single side and double side welded joint

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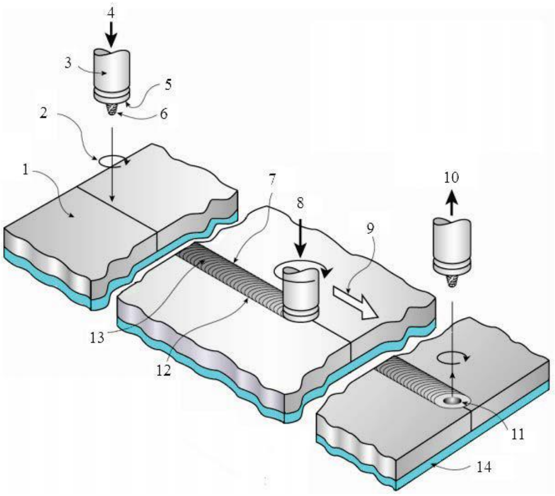
Abstract*— AA 7108 T79 is a recently developed grade of Aluminum alloy which use in production of auto parts such as bumpers, and more recently in load bearing structures such as ship deckings and stiffeners. Friction stir welding is used to weld AA 7108 T79 plates as of it is difficult to make joint using fusion welding processes. In this research work we have investigate the effect of welding input parameters tool rotational speed and welding speed on Tensile strength and Hardness. We performed experiments on single side and double side FSW to find out which parameters have significant effect on weld joint for best weld strength using ANOVA. Also, a comparison study carried out for Double side joint and single side joint for tensile strength and Hardness. We found that 800 RPM tool rotation speed and 80 mm/min welding speed gives better tensile strength. Double side weld joints have superior weld strength than single side weld joint in terms of tensile strength.

***Keywords*— AA 7108 T79, FSW, Double side FSW, ANOVA, Tensile strength**

I. INTRODUCTION

Aluminium alloys with age hardening, such as 2XXX and 7XXXseries are difficult to weld by fusion welding methods. Since it's have wide range of application in automobile industry and aerospace industry due to its good strength to weight ratio and comparatively low cost it is required to use such welding technique that can able to make proper and reliable joint. AA 7108 T79 is a recently developed grade of Aluminum alloy which use in production of auto parts such as bumpers, and more recently in load bearing structures such as ship deckings and stiffeners [10]. Friction stir welding is used to weld AA 7108 T79 plates as of it is difficult to make joint using fusion welding processes.

Friction-stir welding (FSW) is a solid-state joining process (meaning the metal is not melted) and is used for applications where the original metal characteristics must remain unchanged as much as possible. It works by mechanically intermixing the two pieces of metal at the place of the join, transforming them into a softened state that allows the metal to be fused using mechanical pressure, much like joining clay, dough, or plasticine. This process is primarily used on aluminium, and most often on large pieces which cannot be easily heat-treated post weld to recover temper characteristics.



[Figure 1- Friction stir welding technique]

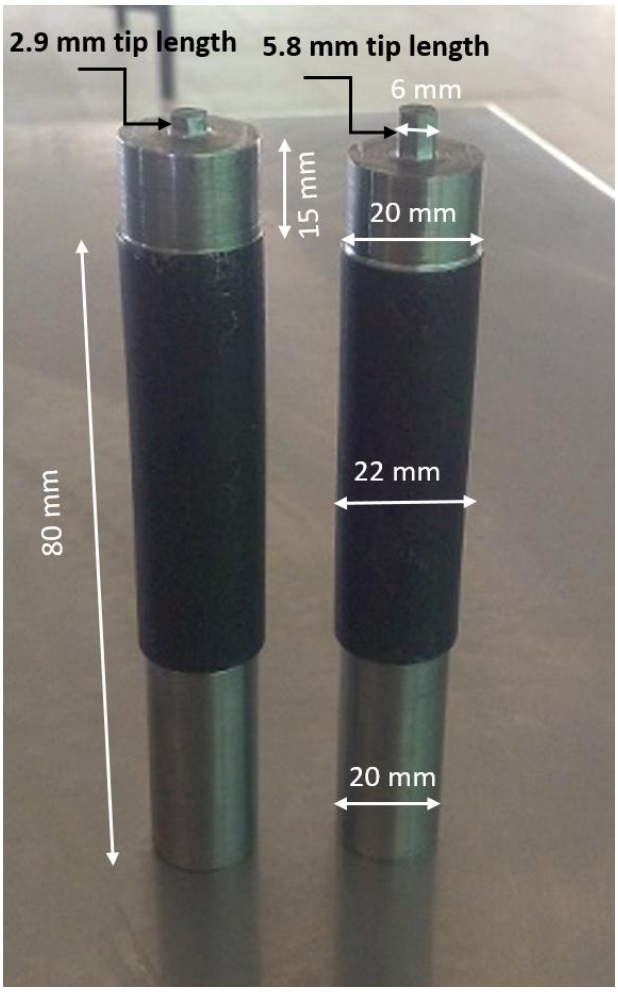
(1 - base metal, 2 - direction of tool rotation, 3 - weld tool, 4 - downward movement of tool, 5 – tool shoulder, 6 – pin 7 - advancing side of weld, 8 - axial force, 9 - direction of welding, 10 – upward movement of tool, 11 - exit hole, 12 - retreating side of weld, 13 - weld face and 14 - base plate)

II. EXPERIMENTAL WORK

The rolled plates of 6mm thickness, AA7108 aluminium alloy, have been cut into the required size (100mm×50mm) by power hacksaw cutting and milling. First 9 experiments are single pass welding procedure has been used to fabricate the joints and double side weld joint with same direction is done for next 9 experiments. No special treatment was carried out before welding and testing. Non-consumable tools H13 with Hexagonal tool profile has been used to fabricate the joints. Two tools used for single side and double side FSW separately their dimensions are shown in Fig. 2(a) and Fig. 2(b). The chemical composition of base metal is presented in Tables 1. Milling machine has been used to fabricate the joints. With full factorial method 3 tool rotational speed and 3 feed there are 9 experiments for single side weld and 9 experiments for double side weld joint have been fabricated in this investigation. The welding parameters is presented in Table 2.

Table 1. Composition of AA7108 alloy (in weight and atom %).

	Zn	*Mg*	*Cu*	*Mn*	*Ti*	*Cr*	*Zr*	*Fe*	*Si*
wt %	5.09	0.91	0.03	0.02	0.01	0.019	0.2	0.21	0.15



[Figure 2(a)- Friction stir welding tool]

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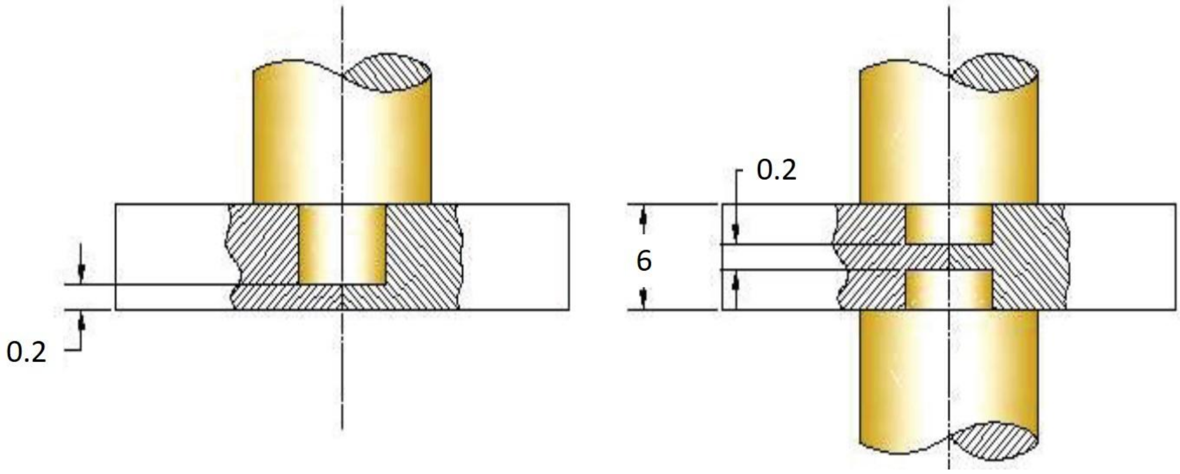
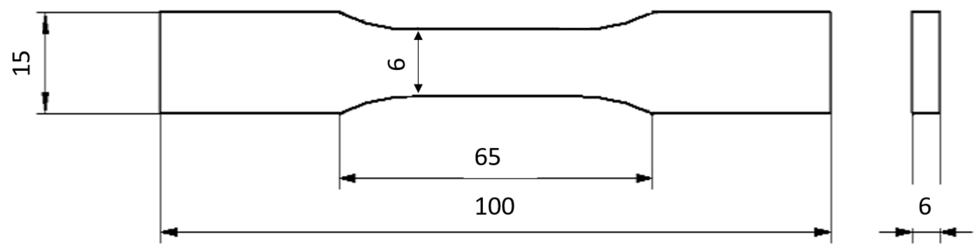


[Figure 2(a)- Friction stir welding tool]

Table 2. welding parameters for single side and double side FSW

Process parameters	***Value***
Tool rotational speed (RPM)	800, 1000, 1200
Welding speed (mm/min)	80, 160, 240
Tool shoulder Diameter	20
Tool Pin Diameter (mm)	6
Tool pin length (mm)	5.8 (single side FSW) & 2.9 (Double side FSW)
Tool pin geometry	hexagonal
Tilt angle	0°

The welded joints are sliced using power hacksaw and then machined to the required dimensions to prepare tensile specimens as shown in Fig. 3. American Society for Testing of Materials (ASTM) guidelines are followed for preparing the test specimens.



[Figure 3- Dimensions of Tensile specimen]

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III. RESULT AND DISCUSSION

A. Tensile test

Tensile tests were carried out for both single side weld joint and double side weld joint Table 3 (a) shows the tensile strength result of double side weld joint while Table 3(b) shows tensile strength of single side weld joint. It is found that for double side FSW 800 RPM and 80 mm/min parameters has the highest weld strength. Also, from fracture analysis it is found that this specimen is broken from parent material while rest of the specimen broken from weld zone. So we can say that weld joint with 800 RPM and 80 mm/min have superior tensile strength.

Table 3(a). Tensile strength for double side FSW

Run No.	*Speed*	*Feed*	*UTS (MPa)*
1	800	80	274.8
2	800	160	234.5
3	800	240	229.8
4	1000	80	241.8
5	1000	160	185.5
6	1000	240	149.2
7	1200	80	174.1
8	1200	160	150.4
9	1200	240	123.4

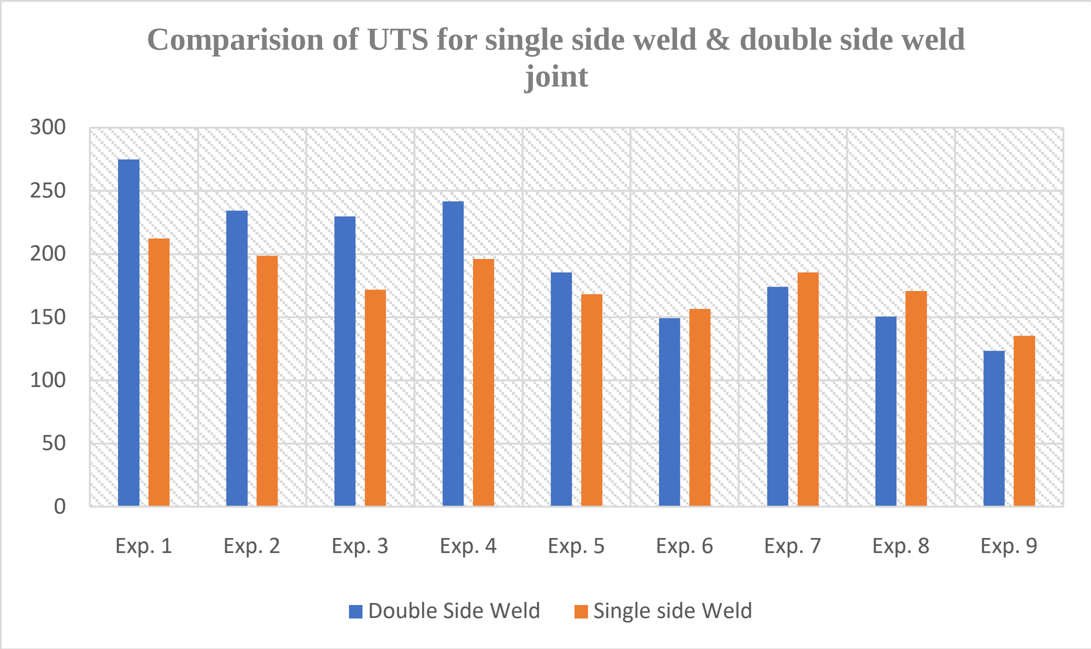
In case of the single side FSW 80 RPM and 80 mm/min parameter have highest weld strength and parameters with high welding speed and tool rotation speed have poor weld strength.

Table 3(b). Tensile strength for single side FSW

Run No.	*Speed*	*Feed*	*UTS (MPa)*
1	800	80	212.4
2	800	160	198.6
3	800	240	171.8
4	1000	80	196.1
5	1000	160	168.3
6	1000	240	156.7
7	1200	80	185.4
8	1200	160	170.8
9	1200	240	135.2

A visual comparison study of UTS for double side FSW and single side FSW has been done. It is found that both type of the joints has highest UTS for 800 RPM and 80 mm/min parameters.

Also, it is found that Double side FSW joints have higher strength than single side weld joint in most of the cases. The rest of the joints which have lower strength compare to single side welded joints are found having tunnel defects.



Exp No.	1	2	3	4	5	6	7	8	9
Speed	800	800	800	1000	1000	1000	1200	1200	1200
Feed	80	160	240	80	160	240	80	160	240

[Figure 4- Comparison of UTS for double side FSW and single side FSW]

B. **ANOVA**

ANOVA helps in formally testing the significance of all main factors and their interactions by comparing the mean square against an estimate of the experimental errors at specific confidence levels. ANOVA test has been carried out for tensile strength and following is the Table 4(a) for single side FSW and Table 4(b) double side FSW

Table 4(a). ANOVA: Speed, feed Vs Tensile strength for double side FSW

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Speed	2	14197.1	7098.6	35.34	0.003
Feed	2	6061.4	3030.7	15.09	0.014
Error	4	803.4	200.8		
Total	8	21062.0			

For double side FSW it is clearly shows that tool rotational speed is the most affecting parameter for ultimate tensile strength which is followed by welding speed.

Table 4(a). ANOVA: Speed, feed Vs Tensile strength for do side FSW

Source	DF	Adj SS	Adj MS	F-Value	P-Value
speed	2	1449.2	724.61	17.80	0.010
feed	2	2842.9	1421.47	34.92	0.003
Error	4	162.8	40.71		
Total	8	4455.0			

For single side FSW from ANOVA table we can say that welding feed is the most affecting factor followed by tool rotational speed.

C. **Hardness test**

Hardness tests were performed to determine hardness of friction stir weldments of AA 7108 T79 for single side as well double side FSW. We can observe that maximum hardness is obtained when tool rotation speed is higher. The hardness profiles were obtained at the middle portions of the weld zone.

D. **Bending test**

Bending tests were carried out to know the crack generation in bending. While performing face bend to 180° crack were found in all the sample Mandrill diameter for bend was 4t. As of the crack on weld zone in all the sample the result of bend test is not satisfactory.

IV. CONCLUSIONS

A maximum tensile strength of 274.8 MPa is exhibited by the double side FSW and 212.4 MPa for single side weld joint is achieved with 800RPM tool rotational speed 80 mm/min feed which was marked highest among the other set of parameters.

From ANOVA table we found the most significant parameter for Double side FSW id tool rotational speed and Signal side FSW is welding speed.

Hardness measures in parameter range of 1200 RPM seems higher than other set of parameters.

By comparing single side and double side FSW for Tensile strength we can conclude that Double side FSW joint have superior weld strength compare to single side FSW joint.

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