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Study of mechanical behaviour & microstructural properties on friction stir welded aluminium alloys 6082 - t6&8011

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Abstract. In this study 6082 T6 aluminium alloys and 8011 aluminium alloys of 5mm Thickness by using a friction stir welding procedure, plates were connected. weldments are carried out by varying various parameters such as Tool rotational rates are varies from(600 rpm,800 rpm,1000 rpm),Traverse speed are varies from(10 mm/min,20 mm/min,30mm/ min) Axial Forces are varies from (4 kn,6 kn,8 kn) and Tilt angle maintains 10.This process performed by nonconsumable tool as Hexagonal,cylindrical and square pin profiles to generate a heat energy and plastic atomic diffusion's are made in the weldments. The fractography microstructure of tensile specimen shows minimum failure when the tool rotational speed is 800rpm, traverse speed at 20 mm/min and axial force 8KN .

Introduction

In recent trends in the welding process Friction stir welding (FSW) is the wide emerging trends in the aerospace, marine, naval & automobile applications by joining the best quality of dissimilar or similar Aluminium, Magnesium and Titanium alloys as a welded plates [1] . while processing the welding techniques non consumable tool fixed with an pin profile touches with anplates' edges that but together be welded, by rotating the tool shoulder creates the frictional force by generating the heat,material get softened and plastic atomic diffusion carried out in the work piece then joining takes place by influence of tool rotational speed and traverse speed, FSW Process is suitable for welding plates and sheets. Rambabu et al demonstrates the findings that reveal the joint structure and corrosion properties are significantly and specifically influenced by the form of the pin profile. The hexagonal tool profile produced the highest quality weld [2].

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The corrosion resistances of friction stir welded AA2219 aluminum alloy joints were predicted mathematically with a 95% confidence level. By combining the welding parameters and various tool pin profiles, the model was created utilizing statistical techniques including design of experiments and regression analysis. Soundararajan et al investigated a welded 8011 aluminium and heat treated 8011 aluminium sample under short peening techniques heat treated sample shows the higher hardness and the yield strength, tensile strength compared to welded aluminium 8011 alloy A specimen of AA8011 that has undergone FSW, heat treatment, and shot peening has higher mechanical and improved tribological qualities, making it suitable for manufacture of components for the aviation, automotive, and railway industries [3][4].

Dharmalingam et. al. analysed the welding variables that affect the hardness and tensile values of welded joints of dissimilar aluminium 7075 and aluminium 8011 Analysis has been done on the effects of the weld speed and rotation rate on the microstructure and mechanical characteristics [4]. R.K.Mishra focused the consequences of uncorroded and corroded aluminium 8011 alloys to study the surface degradation of the alloys for different environmental conditions,8011 alloy exposes the some pits in the surface it will leads to the crack failure, The intergranular corrosion of the alloy was evident from the muddy look of the SEM results that show fracture initiation from corrosion pits.Al alloy 8011, one of many aluminum alloys, has a good balance of flexibility and strength. This is the primary component used to make the heat exchanger fins used in air conditioners, refrigerators, cars, and other cooling systems [5] . K.Palani et al analysed the processing parameters on tensile strength and micro-structure study of an aluminium 8011 H24 and 2024 T6 alloy joints in the nugget zone SiC nano particles SiC nano particles processed welded joints exhibited superior outcomes than the others in the thermo mechanically impacted zone at advancing side, exhibiting a higher percentage of elongation compared to other combinations of the welded joints. The weld nugget zone has tensile strengths of 98.58% and 90.08% [6]. Shalom akhai et al investigated the weld strength of AA8011 and AA6062 aluminium alloys using the response surface methodology approach by rotational speed, welding speed and axial force are taken in to account, welding speed has the least influence on the tensile strength for the selected joints tool rotational speed influences the impact of increases in the tensile strength [7]. Gurgiwala chakravarthi et al focused the Aluminium 8011 similar alloys weld joints material qualities such as tensile strength and hardness by full factorial experiments of design, optimal solution of tensile and hardness with respect to the process parameters by taguchi approach was carried out taper pin profile influences the material qualities after investigating the joints AA9XXX Series aluminium will increase the strength of the factors by goods [8]. Ghosh et al optimized the friction stir welding process parameters of dissimilar aluminium alloys has wide variety of application in defense and aerospace industries demonstrates a significant increase in binding strength compared to the AA 6XXX Series, it inspects between the wrought alloy founded that interface microstructure within the weld nugget zone in retreating side it promotes the finer distribution of SiC in rich and exhibits superior quality [2]. T Joint takes place by using the FSW carried in the dissimilar aluminium alloys in different welding conditions with the existence of the cladding layer two plates are holded in the T joint configuration in the fsw machine and the welding process performes by varying the tool rotational rates and travel speeds with the tapered cylindrical pin [9].To create lightweight bodywork, friction stir welding (FSW) of aluminum alloys is a cutting-edge manufacturing technique. Deformation's impact on FSW's corrosion behavior. Through the use of uniaxial tensile tests, the plastic deformation behavior was identified. These are, nevertheless, the as-welded state's mechanical characteristics and corrosion tendencies. These principles cannot be applied to tailor-welded shaping because FSW joints have undergone significant plastic deformation. It is investigated how an AA2021's plastic metal flow, microstructure, and characteristics are affected by tool shape. The deep groove thread tool pin was best in driving the metal down [10,11] . The finest metal fluidity and the strongest material stirring were found in conical cam thread tool pins [12,13].

In this work the investigations are made on the influencing parameters on the tensile properties and weld strength justified in the hardness, micro-structure evaluation carried out on the various zones of the weldments of dissimilar Aluminium 8011 and Aluminium 6082 T6 Alloys

2 Materials and Composition

2.1 Aluminium Alloys Material details

The Dissimilar Aluminium Alloys of 8011 and Aluminium Alloys of 6082 T6 plates were used for the joining process and High Carbon High Chromium tool is suitable for weld with a dimension of 20mm diameter with shoulder diameter of 12mm with pin profile diameter of 5mm.The chemical combination and characteristics of the aluminum alloys are displayed in the Table 1 AA 8011 Heat treatable alloys and AA 6082 T6 is a Wrought alloys process were made in the FSW Method.

Table 1. Chemical composition of Aluminium alloys

Elements	Si	Fe	Cu	Mg	Mn	Zn	Ti	Cr	Al
AA 6082 T6	0.7	0.5	0.10	0.60	0.40	0.20	0.10	0.25	Balance
AA 8011	0.50	0.60	0.10	0.050	0.20	0.10	0.080	0.050	Balance

2.2 Sample Material Preparation

AA 8011 and AA 6082 T6 plates of 5mm thickness were used to make the Butt Joints by FSW Process with the sizes of 100mm x 100mm.welds are performed by keeping the AA 8011 on Advancing side while the AA 6082 T6 on Retreading side, both the plates are clamped on the bed of the equipment.

2.3 Tool Material Selection

High Chromium High Carbon steel is selected as an tool material for welding Aluminium dissimilar plates, it has characteristics of softening the plates to achieve plastic atomic diffusion of the material takes place, enrichment of chromium content high abrasion resistance and high stability in nature, almost D3 grade is chosen for friction stir welding, varying pin profiles (hexagonal, cylindrical, square) are choosen with the dimensions of shoulder diameter 50mm and pin profile length as 5mm.

Fig. 1. FSW Tool pin profile

2.4 Experimental Design

Prior to joinings are carried out in dissimilar aluminium alloys L9 orthogonal arrays are designed to achieve the weldments by varying the three factors and three levels of parameters are determined.

Table 2. Experimental Design

S.NO	Tool Rotational Speed (TRS) rpm	Welding Speed (WS) mm/min	Axial Force(AF) kn	Tool Profile
1	600	10	4	Hexagonal
2	600	20	6	Square
3	600	30	8	Cylindrical
4	800	10	6	Cylindrical
5	800	20	8	Hexagonal
6	800	30	4	Square
7	1000	10	8	Square
8	1000	20	4	Cylindrical
9	1000	30	6	Hexagonal

Fig. 2. After welded specimen

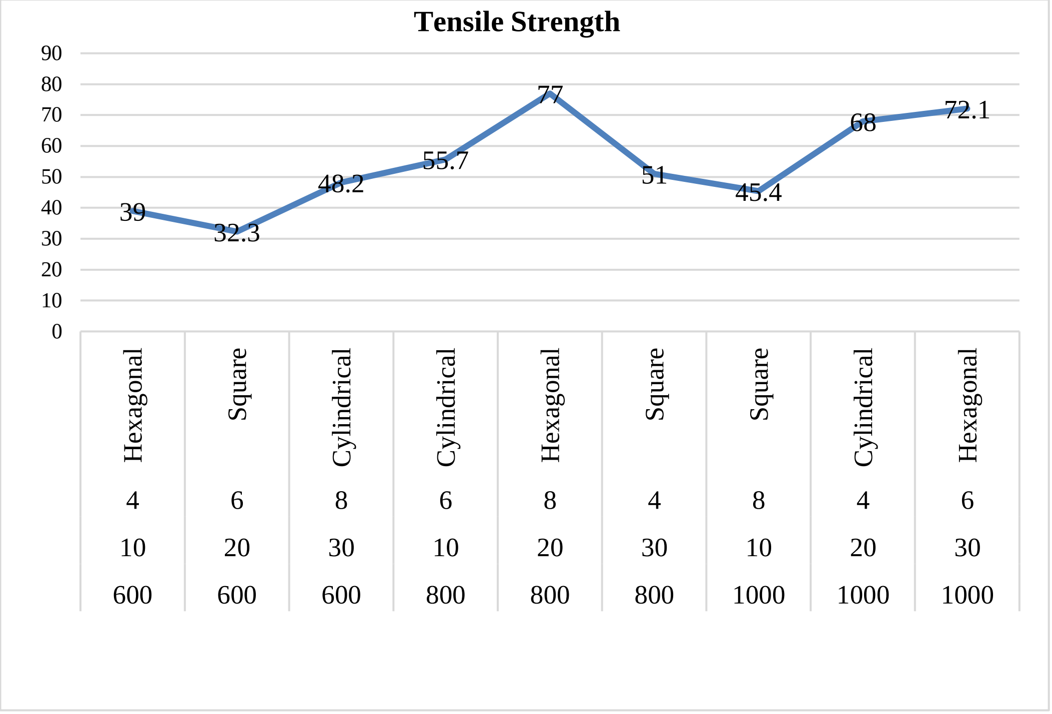
3 Findings and Discussion

3.1 Tensile Test

A Tensile test was performed as per ASME, friction stir welded plates standard dimensions, axial pull of the plates are done by applying the tensile load on the specimen, the graph plotted as per the results analyzed, tensile strength graph is drawn along the coordinates as various parameters showed in the table below vs ultimate tensile strength among the three various pin profiles hexagonal profile welded plates shown the better yield strength as 77.0 mpa in 800rpm, 20mm/min, 8Kn combination and least yield strength was recorded as 39.0 mpa in 600 rpm,10mm/min, 4Kn combination

Table 3. Experimental values of Tensile strengths

S.NO	T R Speed (rpm)	Welding speed (mm/min)	Axial Force (KN)	Tool Profile	Tensile Strength(mpa)
1	600	10	4	Hexagonal	39.0
2	600	20	6	Square	32.3
3	600	30	8	Cylindrical	48.2
4	800	10	6	Cylindrical	55.7
5	800	20	8	Hexagonal	77.0
6	800	30	4	Square	51.0
7	1000	10	8	Square	45.4
8	1000	20	4	Cylindrical	68.0
9	1000	30	6	Hexagonal	72.1



3.2 Hardness Test

Micro vickers hardness testing was carried out to access the hardness properties in the weld region, weld quality was evaluated by the indication of the materials resistance to plastic deformation hardness value will help to find out the weld zone's microstructural modifications In this dissimilar welded joints assessment set no 9 combinations shows the highest hardness of 56.2 HV, set no 3 combination shows the medium hardness value of 53.2 HV, set no 7 combination shows lowest hardness value of 49.5 HV.

Table 4. Experimental values of Hardness value

S.No	T R Speed	Welding SPEED	Axial Force	Tool Profile	Hardness
1	600	10	4	Hexagonal	50.2
2	600	20	6	Square	51.6
3	600	30	8	Cylindrical	53.2
4	800	10	6	Cylindrical	50.2

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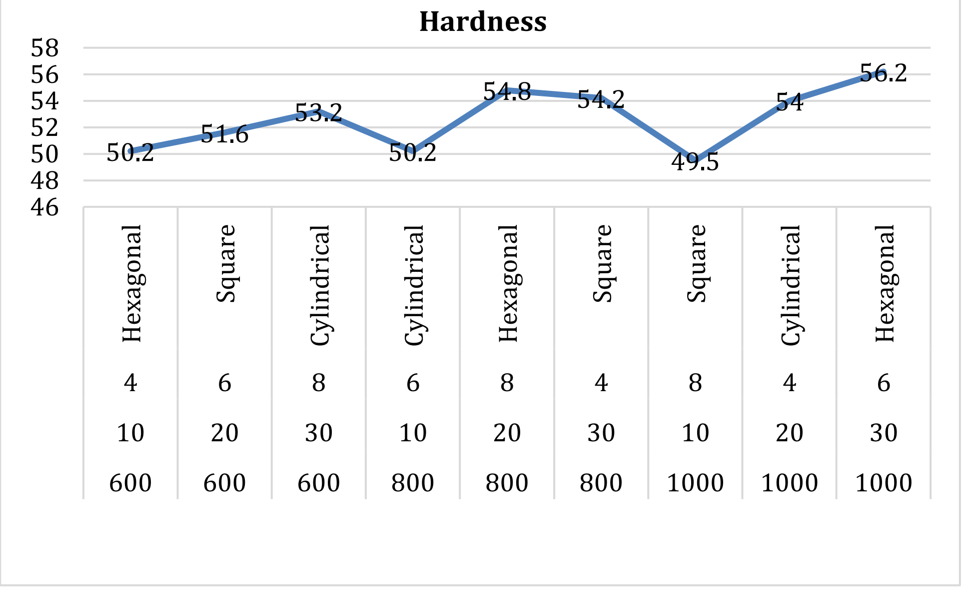
5	**800**	**20**	**8**	**Hexagonal**	**54.8**
6	**800**	**30**	**4**	**Square**	**54.2**
7	**1000**	**10**	**8**	**Square**	**49.5**
8	**1000**	**20**	**4**	**Cylindrical**	**54**
9	**1000**	**30**	**6**	**Hexagonal**	**56.2**



3.3 SEM Analysis

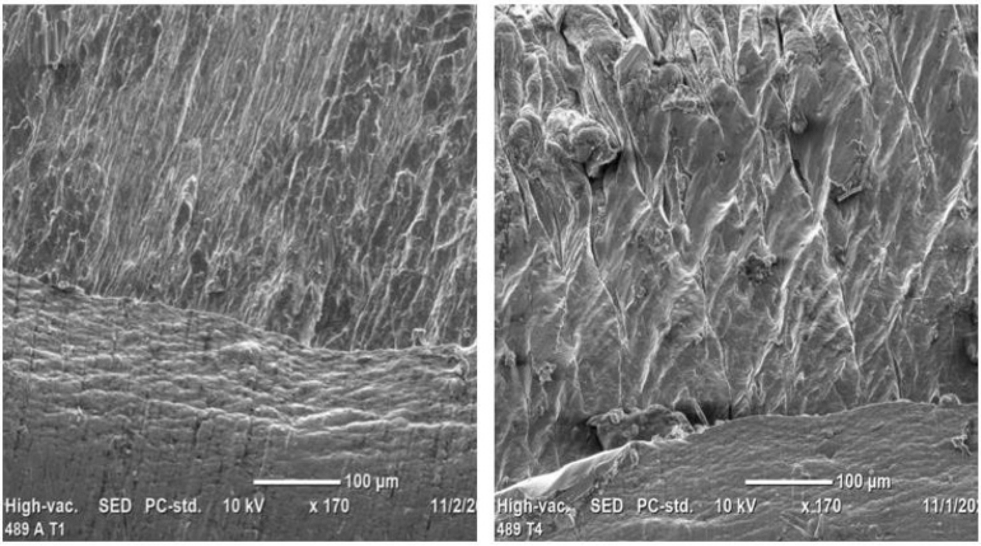


Fig. 3 and 4. SEM fractographs tensile specimens in Sample 1a and Sample b

Understanding failure patterns is necessary; SEM analysis was performed on the tensile tested specimens' fracture surfaces. SEM photos of the FSW joints' top surfaces, middle regions, and bottom sections were taken at three distinct sites; these are shown in Fig. xx 1. Figure 1a shows the tool rotation speed 800rpm, welding speed 10 mm/min and axial force 6KN. The top surface of the FSW zone is marked by the ground-breaking pitch lines created by the spinning of cylindrical tool [14] shown in Fig. 1a. The distance between the innovative pitches shows how ductile the welded joints are. The elongation of the joint is inversely correlated with the distance between subsequent marks. The distance between markers is very modest in AW joints (Fig. 1a), whereas it is considerably large joints (Fig. 1b) which has. Tool rotation speed 800rpm, welding speed at 20 mm/min and axial force 8KN .

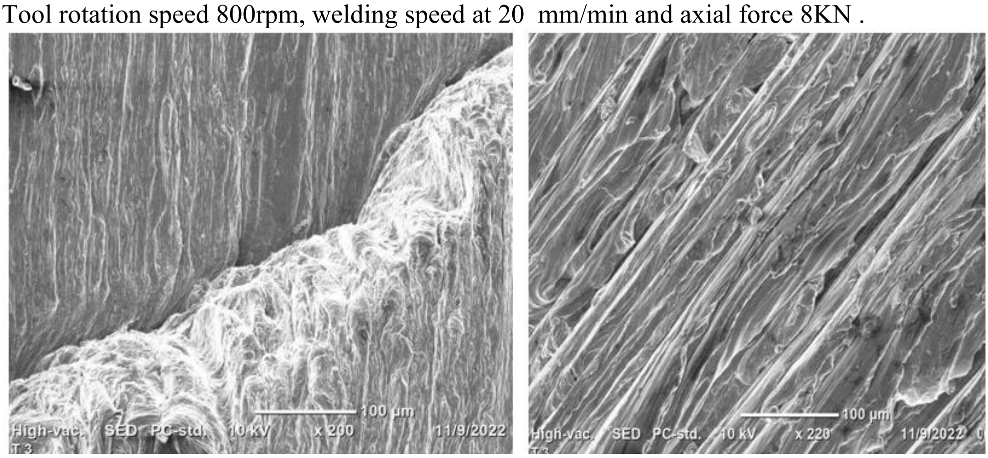


Fig. 5 and 6. SEM fractographs tensile specimens in Sample 1c and 1d

Figure 1C has the tool rotation speed 1000rpm, welding speed 30KN mm/min and axial force 10KNComparatively to the welded connections, the welded joint also exhibits larger spacing between the marks (Fig. 1c). In contrast, the welded joints (Fig. 1d) the tool rotation speed 800 rpm, welding speed 20 mm/min and axial force 10KN have very close marking spacing, indicating a higher degree of elongation. The elongation values seen in the tensile testing are consistent with these marking spacing [15]. Fig. 1d shows the fractographs that were taken at the center of the tension fracture surfaces. The fact that all fracture surfaces contain minimum dimples indicates that ductile fracture is the primary cause of the failure. In ductile material tensile testing, voids typically form before necking which exhiblits high tensile strength.

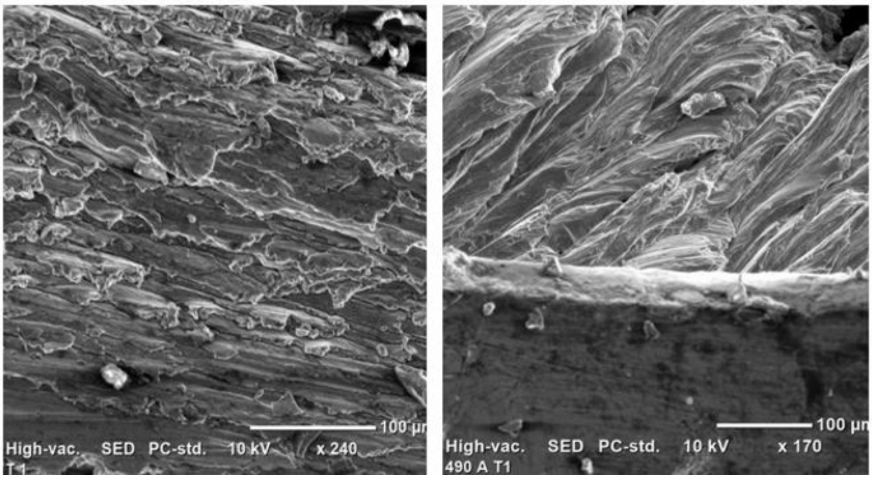


Fig. 7 and 8. SEM fractographs tensile specimens in Sample 1e and 1f

On the other hand, if a neck is produced relatively sooner, as in the welded joints (Fig. 1e), the tool rotation speed 800 rpm, welding speed 30 mm/min and axial force 4 KN with square tool, the void creation becomes very clear and coarse, protruding dimples are apparent.The roots of the broken specimens show cleavage failure patterns. As shown by the fractographs in Fig. 1e. exhiblits the tool rotation speed 1000rpm, welding speed 10KN mm/min and axial force 4KN with same square tool. In contrast to their counterparts, welded joints (Fig. 1e) exhibit considerably larger cleavage facets [16].In ductile material tensile testing, voids typically form before necking which exhibits low tensile strength.

4 CONCLUSIONS

In this current study AA 8011&AA 6082 T6 aluminum alloys were joined by using FSW by varying parameters likely rotational speed, welding speed, various pin profiles & axial forces, it has been found that the tool rotational speed and hexagonal pin profile plays a vital role to evaluate the quality of the joints by indicating the microstructural interface between the weld and the nugget zones, and showing the ability of the tensile and the hardness in the various set of combinations. The results reveals that the maximum tensile strength are obtained from tool rotation speed 800rpm, welding speed at 20 mm/min and axial force 8KN which has a tensile value of 77MPa.where as the hardness of the welded specimen is at tool rotation speed 1000rpm, welding speed at 30 mm/min and axial force 6KN. Also the fractrography images shows the hexagonal tool pin exbhits minimum fracture in the welded area.

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