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Investigation on Mechanical Properties of AA6061 and AA8011 Dissimilar Weldments using Friction Stir Welding

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***Abstract*: Friction Stir Welding of the Aluminium alloy 6061 and Aluminium Alloy 8011 is carried out. The tensile strength and the hardness has been measured and compared with the base material. Mechanical testing procedures are carried out in order to determine the strength of the weld specimen. Tests were also performed to determine the susceptibility of friction stir welded aluminium alloys.**

***Keywords*: Friction stir welding.**

1. Introduction

Friction stir welding (FSW)is a solid state joining process invented at The Welding Institute (UK) in 1991.During the solid state welding process the temperature of welding is less than the temperature of melting point of welded metals. The heat generation caused by friction between the welding tool and weld specimen makes the surrounding material around the tool soft and provide the tool to move along the joint line.

Aluminium alloys are widely used in aerospace, automobiles, railways, bridges, offshore structure topsides and high speed ships because of its higher strength and light weight ratio. Friction Stir Welding(FSW) is a solid state welding process were material to be welded is not melted during welding process, thus the cracking and porosity associated with fusion welding is eliminated. Thus FSW can also be used to weld aluminium alloys to obtain high quality joints. However mechanical properties of FSW have indicated softening in joints of aluminium alloys such as AA6061 and AA8011 caused due to dissolution or growth of strengthening precipitates during the welding thermal cycle, thus resulting in degradation of mechanical properties of the FSW joints. The welding parameters namely rotational speed and traverse speed were considered as the prominent factors which affects the mechanical performance of the welding.

2. Experimental Setup

Friction Stir Welding was conducted on a Friction Stir Welding machine. Parameters are set after welding trails. Work /parent materials dimensions are 100 x 50 x 4 mm. A pair of work piece is clamped on the milling machine table with help of special fixture. The FSW tool has a 20mm diameter shoulder, 5mm pin diameter with 3.7mm length as presented in the below figure. A rotating non consumable made up of high carbon chromium steel plunges into abutting surfaces until the shoulder touches the surface of the work specimen. After a small dwell period the heat required is generated and the table started moving at a predetermined weld speed. Axial force is applied through the shoulder of the tool. The surface temperature of the tool and work interface is monitored. when the plunged tool pin approached near the other end, the entire tool is retracted. the rotating tool pin along with the shoulder during its travel produces frictional heat with temperature below the melting point and the plastic deformation during due to the stirring of specimen around the pin and thus weld is formed. The process is repeated for all welding trails. Samples of the tensile and micro hardness test specimen will be cut in direction normal to the weld in each welded plates and machined as per ASTM E08 standard. Their tensile strength will be estimated using a Universal Testing Machine. Joint efficiency will be calculated by comparing UTS of a specimen with that of parent material of aluminium.

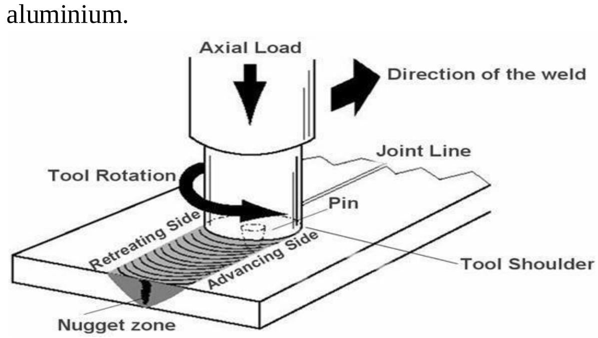
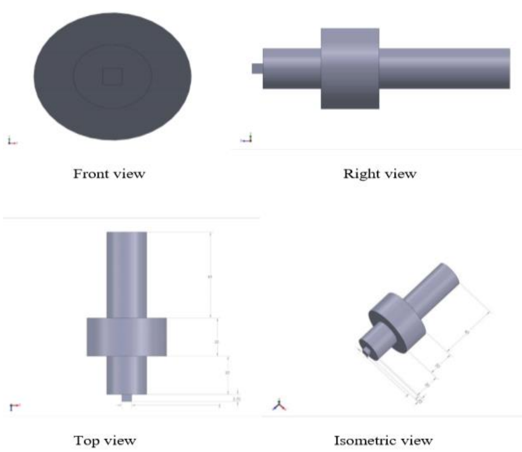


Fig. 1. Friction stir welding

Table 1
Tensile strength

No. of trails	Rotational speed (RPM)	Welding speed (mm/min)	Axial load (KN)	Tensile strength (N/mm^2)
1	1000	30	10	130
2	1000	40	9	137
3	1000	50	8	140
4	1200	30	9	150
5	1200	40	8	146
6	1200	50	10	137
7	1400	30	8	138
8	1400	40	10	139
9	1400	50	9	139

A. Tool Design



B. Process Parameters

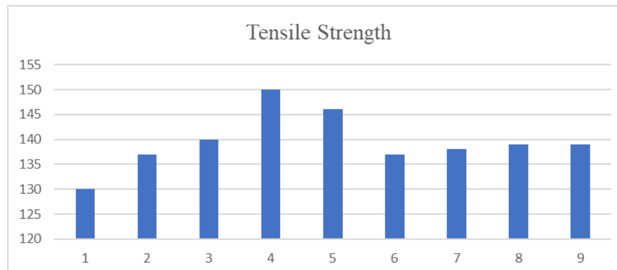
Test case	Rotational Speed(rpm)	Welding speed(Feed) (mm/min)	Axial load(kN)
1	1000	30	10
2	1000	40	9
3	1000	50	8
4	1200	30	9
5	1200	40	8
6	1200	50	10
7	1400	30	8
8	1400	40	10
9	1400	50	9

3. Result

A. Tensile strength

The tensile properties of joints welded at different welding speed are summarized in the table. The maximum tensile strength 150N/mm^2 was achieved at welding speed of 30mm/min. Due to weak bond at joints, the tensile properties of joint decreased at a higher welding speed.

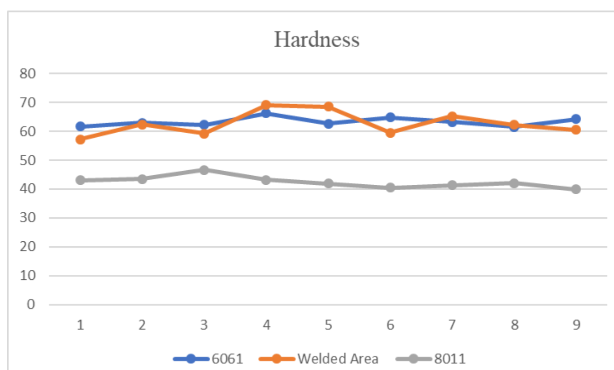
When there is increase in welding speed more than 40mm/min led to the reduction in tensile properties due to the formation of kissing bonds and pores in the soften zones. Thus tensile properties of FSW butt joints of AA6061 and AA8011 plate depended mainly on the welding defects and hardness of the joints.



B. Hardness

Table 2

Number of trials	Base material AA 6061 (VHN)	Welded area (VHN)	Base material AA 8011 (VHN)
1	61.6	57.2	43.1
2	62.9	62.4	43.5
3	62.3	59.2	46.7
4	66.3	69.1	43.2
5	62.6	68.5	41.9
6	64.8	59.5	40.5
7	63.3	65.2	41.3
8	61.5	62.2	42.1
9	64.2	60.5	39.9



Hardness distributions on the of welded joints at welding speeds are shown in table. Minimum affected hardness zone is appeared on AA6061 and the value get increased as welding speed increases. Also softened zones existing on both the sides of the heat affected zone were shifted towards the centre line as the welding speed was increased. The softening of hardness of HAZ in the joints can be attributed mainly to the coarsening of precipitates where lost their coherency with the matrix due to the thermal history

The scattering of hardness value in the soften zone will result in formation of onion ring pattern that consist of bands having chemical composition which is similar to those 8011 alloy (lower hardness) and 6061 alloy (higher hardness). Hardness in the TMAZ were slightly decreased when comparison with the base metals.

4. Conclusion

The detailed study of aluminium alloy and friction stir welding are carried out. The fixture has been designed for clamping the work piece, because work pieces should be fixed rigidly in the FSW process. High carbon chromium tool was fabricated with the required dimension. The welding parameter are rotational speed, welding speed and axial load. The trial weld was carried out with different parameters using orthogonal arrays method for welding process. The tests were carried out with Tensile strength test, Hardness test has been done and compared with the base materials. Thus, comparing all the specimens, specimen 4 has high tensile strength of 150 N/mm with rotational speed of 1100rpm, welding speed of 30mm/min and axial load of 9KN shows the best result. Comparing hardness of all trials, specimen 4 shows the highest hardness value of 69.1HV. Hence we shall consider the above values of parameters as optimum values for producing high tensile strength of aluminium alloy taken in this study.

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