Friction Stir Welded Joint Efficiency of Aluminium Alloy 6061-T6

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Abstract:

Friction stir welding is a Solid state welding process which can produce low cost and high quality joints. This is because it does not require the consumable filler materials and can eliminate some welding defects like crack and porosity. The main objective of the present study is to check the Weldability of Aluminium Alloy 6061-T6 using Friction stir welding and to determine the weld strength. Experiments are conducted at rotational speed of 900 RPM, Welding speed of 40 mm/min, axial force of 5KN and Title angle of 0^0 on 6 mm thick AA6061-T6 alloy plates using friction stir welding. A Cylindrical Taper tool of High Speed Steel with shoulder diameter of 22 mm, Pin diameter of 7mm and pin length of 5.8 mm is used for friction stir welding. Tensile strength of friction stir welded joints of AA6061-T6 specimens are tested on UTM and Tensile strength and stress strain curve are recorded.

Keywords: Friction Stir Welding, Aluminium Alloy 6061-T6, HSS Tool, Process Parameters, Tensile Strength, Stress-Strain curve.

I. Introduction

Friction stir welding (FSW) is One of the best technologies that have been identified to join low-temperature alloys especially aluminium and have been successfully employed to join aluminium alloy in many applications such as in marine, military, automotive and aerospace industries [1]. The concept of FSW is simple; a rotating non-consumable tool with a specially designed shoulder and pin is inserted into a butting edge of plates or sheets to be joined till the shoulder contact the top surface of work piece and traversed along the line of joint to produce the weld.

The tool serves primary functions are heating of work piece, deform the material and movement of deform material to produce the weld. The heating is accomplished by friction between the rotating tool and the work piece and plastic deformation of work piece. The localized heating plasticize the material around the pin and combination of tool rotation and translation leads to movement of material from the front of the pin to the back of the pin. Due to this process a joint is produced in "solid state" [2]. Tensile strength and micro Hardness in nugget zone was increased due to presence of Al_2O_3 nano particles. Fracture under tensile loading occurred on the advancing side due to the accumulation of Al_2O_3 nano particles in HAZ [3]. The type of reinforcement and percentage of reinforcement has a major effect on the mechanical properties of friction stir welded joint of aluminium alloy 6061 [4-5]. The tensile strength and hardness of the joints can be improved about 16% and 12.5% respectively by applying water cooling condition. Also, research findings showed that the elongation is deteriorated by applying cooling condition and reaches from average values of 10.46%–6.98%. From microstructure analysis, it was found that grain refining and prevention of heat affected zone from softening are main mechanisms for improving the welding strength and hardness. Also, residual stress distribution showed that applying water cooling to FSW process causes increase of magnitude and depth of compressive residual stress that significantly reduces the deflection of the sample after unclamping [6]. The micro hardness and strength of Friction stir welding of aluminium alloy 6061-t651 increased when the transverse speeds are increase. The micro structure of welded specimen showed that the grain size become smaller by increase the transverse speeds [7].

II. Experimental procedure

II.I Welding set up

The Aluminium plate 6061-T6 with a thickness of 6 mm to be welded was cut into pieces of 200 mm (length) × 100 mm (width) each as shown in figure1. The edges to be joined were milled to allow proper lapping when placed in the welding position. The surface especially the areas to be welded were cleaned with very smooth emery paper to remove oxide layers that might have been formed on the surfaces of the alloys. Ethanol was further used to clean the surface to remove dirt and oil or grease. A cylindrical tapered tool having shoulder diameter of 22 mm, probe length 5.8 mm, with root and mouth diameter of 7 mm and 6 mm, respectively as shown

in figure 2 was used for the welding. The welding was carried out on vertical conventional milling machine shown in figure 2. The plates were arranged in butt configuration. The welding parameters like rotational speed of 900 RPM, Welding speed of 40 mm/min, axial force of 5KN and Title angle of 0^0 were utilized for the welding. AA6061-T6 specimens are welded as shown in figure 3.

Figure1: Base Material AA6061 (200X100X6 mm)

Table 1: Composition of Base Material AA6061-T6

Alloy	Cu	Mg	Si	Fe	Mn	Others
AA6101	0.1	0.7	0.5	0.5	0.1	0.1

Figure 2: HSS Tapered Tool

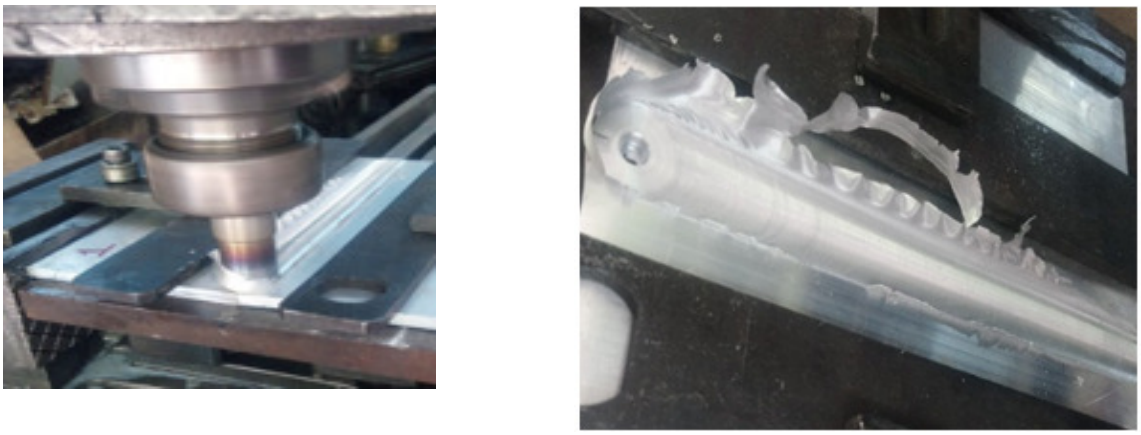

Figure 3: Friction Stir Welding of AA6061

II.II Mechanical testing of the welds

Two tensile samples of weld as shown in 4 were cut perpendicularly to the weld following ASTM E8 standard specifications for mechanical strength evaluation. The tensile testing was carried out using Nano UTM as shown in figure 5. Tensile strength and stress strain are recorded.

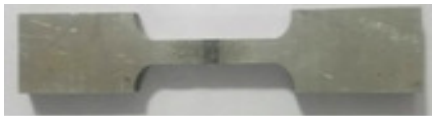

Figure 4: Tensile Specimen as per ASTM E8

Figure 5:Tensile Testing on Nano UTM

Figure 6:Tested Specimen

III. Results and analysis

The Tensile strength of friction stir welded specimens are recorded as shown in table 2.

Table 2: Tensile Strength Test results

Property	Trial-1	Trial-2	Average
Peak Load kN	4.874	4.763	4.818
Tensile Strength (Mpa)	135.383	132.848	133.848
Percentage of Elongation	17	15	16

The average Ultimate tensile strength of friction stir welded specimen of AA6061-T6 is 133.848 Mpa, Average Peak load is 4.818 kN and average percentage of elongation is 16. Ultimate tensile strength of base material is 221 Mpa and percentage of elongation is 19.

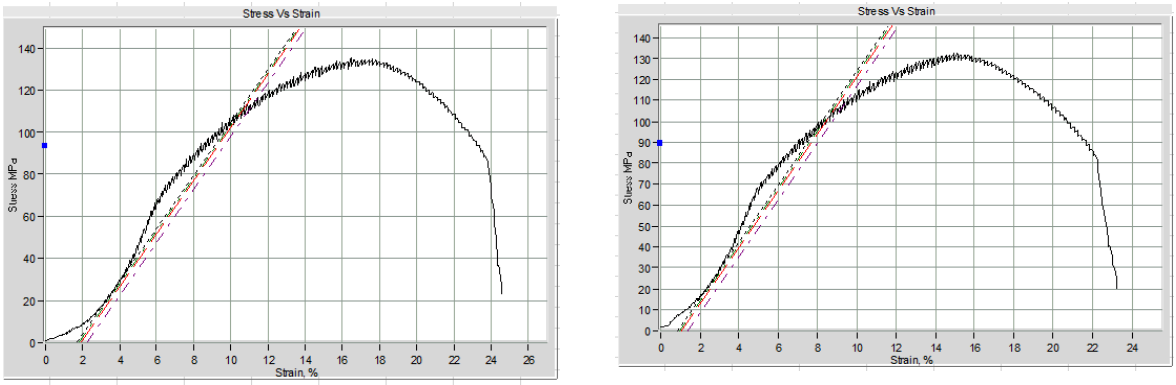

Figure7: Stress Strain Curves of Tested Specimens

IV. Conclusions

Aluminium Alloy 6061-T6 plates of 6mm are welded successfully using friction stir welding. It has been observed that the ultimate tensile strength and percentage of elongation of friction stir welded joints is less than the base material Ultimate tensile strength and percentage of elongation. The ultimate tensile strength of base material and welded specimen is 221 Mpa and 133.84Mpa respectively. It has been observed that the weld efficiency of friction stir welded joint is 60.5 only. This efficiency is very less. So enhancement of weld efficiency is required. This research is stating that the friction stir

weld efficiency is very is less, so enhancement of weld efficiency is required. It can be enhanced by varying the process parameters of friction stir welding process, by varying the tool geometry and by making metal matrix composite at weld portion.

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