Friction Stir Welding of Aluminum Alloy (6082): A Review

Vikas Rohilla, Pardeep Gahlot, Adarsh Bhoria, Shailesh Kumar Pandey

***Abstract:** This paper focused on the Mechanical and Microstructural changes of aluminum alloy 6082-T6 welded joints formed by Friction Stir Welding Technique by varying process. Parameters such as tool rotational speed, welding speed, shoulder geometries, tool tilt angleetc. This paper have not any Experimental procedure and values because it is only a Review to gain knowledge about the Mechanical and Microstructural changes and it's Analysis. The effect of various process parameters on Micro hardness of the joints is also studied. As FSW joining takes place below the melting temperature of the base material Due to which all the defects related to melting is automatically removed. The review helps in selection of important process parameters as the quality of weld joint depends on these welding input parameters and in optimization of these parameters.*

***Keywords:** Friction stir welding, Mechanical properties, process parameter, Microstructure process parameters.*

I. INRODUCTION

Aluminum metal is easily available in earth crust and it is the third most abundant element in the earth's crust by mass. So now a days, Aluminum alloys are mostly used in place of steel because Aluminum alloys have many useful properties as compare to steel such as excellent corrosion resistance, light in weight as having one third density of steel, easily mach inability, good thermal and electrical conductivity etc. Due to These properties it has high-demand in industries mainly in the automobiles, aerospace, in making many ship parts, in buildings for many applications such as roofing, etc. It is used for all these applications due to its high strength along with suitable ductility. Aluminum alloys can't be directly used for these application, we have to weld them for different uses. The most suitable methods for welding aluminum alloys is Friction Stir Welding becausebyother methods such as Tungsten inert gas(TIG) and gas metal arc welding(GMAW) produces many defects such as pores, lack of fusion ,incomplete penetration, create many cracks such as hot crack, stress corrosion, due to these defect strength of the weld joint can be loss[1]. To overcome all these problems, Friction Stir Welding is used for Aluminum alloys .

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Friction stir welding is an innovative welding process in which welding is done at the solid state it was invented in 1991 by The Welding Institute and it is one of the most significant developments over the last many years[2].

II. WORKING PROCESS AND PRINCIPAL

Friction Stir Welding is a solid state joining technique in which the material to be joined is plasticized by heat generated due to friction between the surface of the plate and the rotating surface of a special tool. This special tool has two parts(a)shoulder (b) pin. Both have their different function. Shoulder is responsible for the generation of heat, while pin mixes the material of the components to be welded, thus creating a joint (Fig.1). A cylindrical tool having shoulder and pin rotates with a high speed and plunged into the plates which have to be welded and moved along the joint. A continuous downward force is maintained during the motion of the tool along the line of action. Heat is generated due to friction occur between the plates which is to be welded and the rotating tool and joining takes place below the melting temperature of the base material. As FSW joining takes place below the melting temperature of the base material. Due to which all the defects related to melting is automatically removed. Thus a defect-free weldis produced with good mechanical properties.

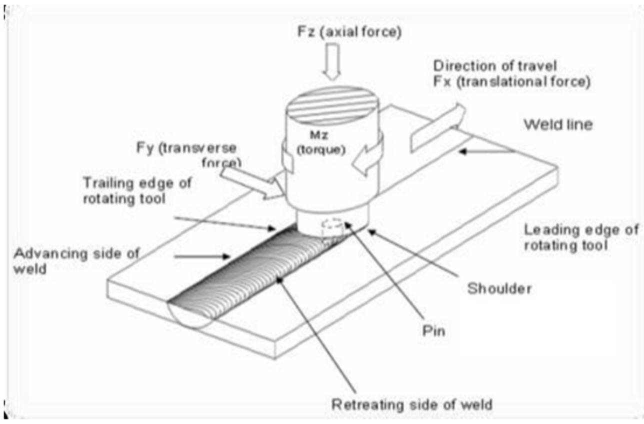

Figure 1 Schematic Diagram of the Friction Stir Welding Process

The shapes of the pin can be Square, Triangular, Pentagon, Hexagon etc. according to application. The shape of the Shoulder should be concave because when shoulder is plunged into the plate to be welded and as they are fixed on the another plate which is just below them then the material from the specimen try to come out and adjust inside the concave shape of the shoulder.

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Friction stir welding is the generally used for some aluminum alloys that cannot be welded by the fusion welding techniques. Sometime it produces a weld joint that is stronger than base metal.

III. LITERATURE REVIEW

P. Cavaliever F. Panella et al (2007): studied the effect of process parameters on mechanical and microstructural properties of Aluminum alloy 6082 joints formed by Friction Stir Welding FSW was produced by keeping rotational speeds at 1600 rpm but welding speed was changing from 40 to 460 mm/min for the evaluation of the mechanical properties tensile tests were performed at room temperature. Welding parameter was used to analyze microstructure evolution of the materials. The base metal used for studied is aluminium alloy 6082-T6 with 200 × 80 × 4 mm dimensions rectangular plates. Rotational speed of threaded tool was constant at 1600 rpm while speeds were varied 40, 56, 80, 115, 165, 325 and 460 mm/min. shoulder diameter was 14 mm and tilt angle equal to 3°. The pin of tool was 3.9mm long, having a diameter 6.0mm. At all these welding speeds and at 1600 rpm rotational speeds the micro structural behavior of 6082 aluminum alloy was studied by using optical microscopy. It was observed that different grain size and distribution occurs for various travel speed; the recrystallization in microstructure of the material appears up to 115 mm/min. but due to different temperature it was not uniform and true strain formed at lower speed. When the travel speed increased the nugget microstructure becomes fine as well as uniform. When the speed is increased from 40 to 165 mm/min. a large variation was observed but there were no further variations when speed was increased up to 460 mm/min. The effect of temperature on microstructure of the material have very important role. It was observed was that if the temperature is low in the nugget zone then force acting on the material is not able to proper plastic flow for a recrystallization process but when the temperature is increased even at low travelling speed the material is soften and growth in grains after deformation on be observed. From the experiment the yield strength and the ductility also observed at these various speeds. It was observed that yield strength increased rapidly, when the speed is increased from the lower value to 115 mm/min. the yield strength at maximum yield point was approximate 185 MPA and starts decreasing again with increase in speed. The ductility of the material also showed the same behavior but it started again to increase after 165 mm/min. At around 115 mm/min tool speed elongation equal to 11.6%. [3]

Sakthivell et al (2009): Studied the influence of various welding speeds by varying from 50mm/min to 175 mm/min on the mechanical and metallurgical properties of the similar or dissimilar alloy. It was found that base material have ultimate tensile strength of 84 MPAwhereas from the experiment it was noted that at low welding speed of 50mm/min the ultimate tensile strength was around 80 MPA On the other hand at higher welding speed 175mm/min, tensile strength was 71 MPA So it conducted that on increasing transverse speed, tensile strength decreased due to inadequate heat input as at lower speed, due to which recrystallization takes place at lower speed, due to which the grain size increased and restoration of the ductility.[4]

A. Scialpi, L.A.C. De Fillippis et al (2006): studied the effect of various shoulder geometries on the mechanical and microstructures properties of Friction Stir welded joints. In his study, he used Aluminum alloy 6082 as a base metal of thickness 1.5 mm and welding was done at 1810 rpm of tool rotational and feed rate was 460 mm/min, with a 2° tilt angle and plunge depth 0.1 mm. A non-threaded pin of 1.7mm diameter and 1.2mm height was used to plunge for the experiment three different types of shoulders geometries such as only fillet, scroll and fillet, cavity and fillet were considered. From the experiment it was observed that tool with fillet and cavity produced a smooth crown with very little flash as compare to other two because both fillet and cavity in combined form increases the longitudinal and transverse strength of joint and produces the best crown surface [5]

T. Minton & D.J. Mynors (2006): Investigated whether friction stir welding can be done on conventional milling machine or not, on a Parkson vertical Mill type a machine, by using 6082-T6 aluminum sheets of 4.6mm thickness and 6.3mm thickness. For conducting experiment a truncated tool was designed for 4.6mm sheet and a single generic tool for 6.3mmsheet having 19mm diameter of silver steel. The pieces to be welded, are kept in the form of the butt joint and fixed on the baking plate of the machine’s feed table. For FSW four levels A, B, D and E was designed according to the spindle speed, feed speed and tool tilt angle. There were four points 1, 2, 4 & 5 for which values to be determined. Several trials were done in the first sets maximum was speed was kept and indicated point A. There was reduction in feed sped in steps, working towards B. by setting maximum spindle speed at 1550 rpm, the minimum feed speed was observed for the 6.3 mm and 4.6 mm sheets and feed speed is reduced in steps from 3.175 mm/sec which was maximum. Similarly by reducing spindle speed from maximum to minimum (620 RPM) and setting feed speed of 0.2646 mm/s, the minimum spindle speed was determined. 1, 2 and 4 were determined with the coordinates of point and 5 was assumed from symmetry many number of welds were done and tested such as tensile ad hardness results indicated that milling machine is capable of producing good quality welds with less optimality for both 4.6 mm aluminum sheets and 6.3 mm thickness sheets but the quality of welds of 4.6 mm thickness is lower than 6.3 mm thickness [6].

Magdy M. El-Rayes, Ehab A. El-Danaf et al (2012): Studied the effect of multiple passes on the micro structural and mechanical properties of AA6082. Aluminum alloy 6082 plates having 120 mm length, 100 mm width and thickness 6mm were used. During experiment Friction Stir process was used in which tool rotates at constant speed around 850 rpm by applying one, two and three passes in such a way that overlap each other. The tool was used with a flat shoulder of 15mm diameter and a square pin of 5mm long. The FSP runs were performed in the perpendicular direction to the rolling direction.

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Grain size were increased with increase the number of passes keeping transverse speed constant. It was observed that when the number of passes is increased one by one it reduced the ultimate tensile strength and soften the material. On the other hand strength and hardness increased on increasing the transverse speed. [7]

P. Cavaliere A. De. Santis et al (2009): Studied the effect of process parameters on the properties such as mechanical and microstructure of dissimilar alloys AA6082-AA2024 joints produced by Friction Stir Welding for the experiment a conical shape tool of C40 steel tool with a diameters minimum 2.8 mm and maximum 3.66 mm was used, the shoulder diameter was 9.5 mm. The rotational speed remains constant at 1600 RPM but advancing speed of the tool changes from 80 to 115 mm/min. To determine mechanical properties, micro hardness tests of all the welded zone were determined by using a Vickers indenter with a 5N head for 15 sec. Tensile test also done at room temperature by using a MTS 810 testing machine. During FSW process when the 2024 alloy was kept on the advancing side and welding speed was 115 mm/min then highest values of micro hardness were observed. But when 6082 alloy was kept on the advancing side the micro hardness profile to be more uniform which show better mixing of material. But minimum micro hardness is observed in heat affected zone because the heat affected zone deformed very less. The tensile properties were studied at different welding conditions of dissimilar joints obtained by FSW. When the welding speed increased, the tensile strength also increased by keeping 6082 on advancing side. The best tensile properties for dissimilar joints of AA6082 & AA2024 obtained at advancing speed of 115 mm/min. Similarly ductility of the joints also increased with the increase of weld speed [8].

IV. CONCLUSION

The present study focused on the microstructural and mechanical properties of Friction Stir Welding joints of aluminum alloy 6082.All the cases evaluates the welding performance of FSW process. It is found that mechanical properties of Friction Stir Welding joints of AA6082-T6 Changing with changing process parameters and tool geometry. The process parameters and tool geometry also affect the microstructural properties. Thus it proves that, proper selection of process parameters and suitable tool geometry are important for getting good welded joints formed by Friction Stir Welding.

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