A Review on Friction Stir Welding of Aluminum Alloy (7075)

Shailesh Kumar Pandey, Pardeep Gahlot, Vikas Rohilla, Manish

Abstract: ***Friction stir welding is a solid state joining process and is extensively used for aluminium alloys. In a given work it was analyzed that how the tensile strength as well as microstructural behavior of AA7075 varies if the process parameter like axial pressure force, welding traverse speed and rpm of the FSW tool varies to butt weld of two pieces having length 100mm, width 50mm and thickness 6mm have been used. It was preferred friction stir welding process to obtain the particular result over traditional welding process because of no melt of piece, no toxic fumes and harmful radiation which is suitable for environment so FSW is eco-friendly welding process. It can be widely used in aircraft, marine, automotive as well as railways industry because of eco-friendly in nature.***

Keywords: ***Friction stir welding, Welding speed, microstructure, Tensile strength, Rotational speed***

I. INTRODUCTION

Friction stir welding is a recent welding technique, invented by The Welding Institute (TWI), UK in 1991. In this process we utilizes a rotating tool which is non-consumable welding tool to generate heat by friction and deformation at the place of welding location, therefore affects the formation of a welding joint, while the material remains in solid state. Friction Welding techniques, if it is compared to traditional welding techniques, reduces the chance of distortions and residual stresses and is being widely used by modern aerospace industry for high performance structural applications. On the basis of friction heating at the facing surfaces of two sheets which is to be joined in the friction stir welding process a special tool with a properly designed rotating probe along the contacting metal plates, produces a highly plastic deformed welded zone by the stirring action. This type of alloys are difficult to join by conventional fusion welding process. This paper aims at enhancing the possibility of welding this alloy using friction welding techniques.

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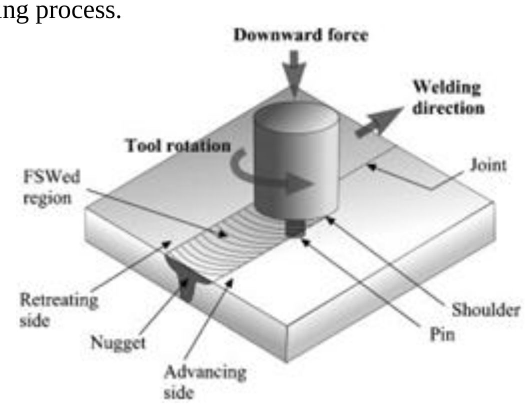
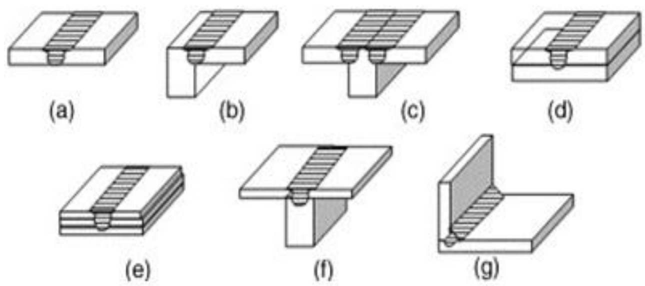
Hardness value, tensile strength as well as Microstructural behavior of the 7075 aluminium alloy was studied. Comparing to the fusion welding technique this is used for the joining of structural alloys.

Friction stir welding is to be the new upcoming solid state joining technique in which the material which is being weld does not melt. So friction stir welding is considered as a welding which is suitable for the environment because of the absence of various dangerous gases coming from the fusion welding process.



Schematic Diagram of FSW Process



Different Types of Joint by FSW Process

II. WORKING PRINCIPLE OF FSW

In FSW process a threaded profiled pin of a cylindrical shouldered tool rotates and plunged into the joint area between the pieces to be joined. The part which has to join is to be firmly clamped so that the welding takes place very accurately and also in an efficient manner. In this process spindle apply downward forging force. This process is very simple in nature and also uses simple method to produce welding. In this process tool moves continuously until the whole process to be completed and thereafter tool separates from the work piece but hole which is created by tool pin during welding process remains on the plate itself.

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III. PROCESS PARAMETERS OF FSW

Friction stir welding is that the parameters can be controlled thus controlling the energy input to the system. The TRS and the WS are the two most important process parameters.

The tool geometry (size and profile) and the process parameters affect the heat generation, material flow, microstructure evolution and the properties of the joint. In this technique the tool life is very important factor which depends on the process parameter and to obtain a parameter which is more suitable for the properties of friction stir welding process as well as to know the consequences of the influence of these parameters on the microstructural behavior of welding to be done. The influence of some of the important parameters such as axial pressure force, speed of rotation, tool tilt angle, shoulder and pin diameter, welding speed which affect weld properties have been investigated. Hence, in this investigation an attempt has been made to understand the effect of tool parameters and process parameters on FSP zone formation and related tensile strength properties of friction stir welded AA 7075-T6 aluminum alloy joints. Important parameters such as axial tool pressure (F), rotational speed (N) and traverse speed (S), on weld properties have been investigated, Nansaarng and Chaivanich (2007), Azimzadegan and Serajzadeh (2010). But, few investigations, Jayaraman et al. (2009), Lakshminarayanan and Balasubramanian (2008), Nourani et al. (2011) have been performed on formulization and optimization of effects of FSW parameters on mechanical and metallurgical properties. Taguchi method is a very important techniques which was used to optimize the metallurgical behavior in past history, Karnyabi-Gol and Sheikh- Amiri (2010), Anawa and Olabi (2008), Saigal and Leisk (1992). A.K Lakshminarayanan et al. (2009) describe friction stir welding by best possible process parameter which was approx 1150 to 1200 rpm rotational speed, 7 KN axial pressure force and 75 mm/min welding speed, this procedure exhibited yield strength of 225MPa, and tensile strength of 247MPa, which was approx 35% more than other welding joints and the microstructure contain very fine and equiaxial grain.

IV. LITERATURE REVIEW

Acerra.F et al (2010) attempted to weld the combination of two dissimilar aluminium alloy in T-configuration of AA7075-AA2024. It was to be investigated that higher the shoulder diameter of tool higher the heat to be generated by the FSW process on the weld zone. It was done to fulfill the forging requirement. Sometimes coating blank elements was obtained causes major defect was analyzed. [1]

Buffa et al (2006b) studied the model simulation in which he investigated how the tool geometry affect the weld zone. He tried with conical as well as cylindrical geometry of the tool and advancing speed of FSW on rigid visco-plastic three dimensional finite element model of 7075 aluminium alloy. In this model he studied how material flow takes place over the weld to be done as well as microstructural behavior like grain size variation. This result was used further to find the optimum tool geometry as well as speed to be advance. [2]

Cavaliere et al (2005) and Cavaliere et al (2006b) studied the microstructural behavior and mechanical properties of 7075 and 2024 aluminium alloy to be weld by Friction stir welding process. Difference of grain structure and precipitate distribution were caused by FSW process. Highly fine smaller grain was obtained having shape looks like Elliptical onion ring at the center of the weld and also the micro hardness profile was increased and started descending in every two mm until the hardness to be reached same as the base material. It was found to be fine and equiaxial grain around the nugget. It was analyzed that the repeated failure fatigue life was increased. [3]

Colegrove and Shercliff (2004) studied the flow of material during friction stir welding process using the model based on CFD. This model was used to obtain the flow of material to all around of Trivex as well as MX-Trivex tool. The result which is to be obtained was compared to the analysis result of Triflute tools. By using trivex tool the analysis was indicated that the downward force as well as transverse was decreased. To know the behavior of material flow the stream lined around the tool was used. The force along the downward direction was found to be increased using Triflute tool. [4]

Da Silva et al (2011) studied flow of material, microstructural behavior, mechanical properties like tensile strength and hardness based on variation of process parameter and their effect on weld to be done by friction stir welding joints of two dissimilar alloys between AA2024-T3 and AA7075-T6. Boundary the between of base metal all around the stir zone was clearly observed as well as no onion ring formation to be observed. [5]

Fratini.L et al (2006) also studied how material flow takes place in Friction stir welding process of aluminium alloy 7075. He followed the process of numerical simulation as well as experiment by taking the variation of tool rotation speed, welding traverse speed as well as changing the shape of the profiled pin. It is to be founded that the bonding of the material occurred to the advance side of friction stir welding joints. The material flow was found to be uniform when geometry of the tool profile was conical because it allows vertical material movement so avoid the formation of the defect. [6]

Khodir and Shibayanagi (2008) studied and presented what are the effect of process parameters like welding speed and also the location of the base metal in the microstructure obtained also the mechanical properties like tensile strength and hardness distribution of the joints made by Friction stir welding process of 7075-T6 and 2024-T3 Al alloy. The defect which is called as kissing bond defect is appears on weld zone when the speed of weld is increased. Onion ring pattern obtained by different equiaxial grain sizes and non-homogeneous distribution of alloying element was obtained. Hardness of heat affected zone was found to be very- very low. The specimen which is having defect was failed in stir zone (SZ) and defect free specimen in heat affected zone (HAZ).

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The result was investigated and founded that while locating 2024 aluminium alloys in advancing side so that the mechanical properties like tensile strength was increased to 423 MPA with the welding speed of 1.63 mm per second. [7]

Mahoney et al (1998b) studied longitudinal as well as transverse properties of Friction stir welding because of thermal aging of 7075T651 aluminium alloy.

It was found to be weakest heat affected zone cause lowering the tensile strength as well as yield strength along with the hardness. The longitudinal as well as transverse tensile test was carried out to check the strength in this particular direction. Thermal aging was done after welding known as post weld thermal aging which increases the value of fine hardening precipitates causes increase in hardness and strength but decrease in ductility of weld to be done. The inter-granular structure was found at the grain boundary which is highly unstable where grain shape and its form changes and this was free of precipitates commonly known as precipitates free zone (PFZ). Transverse tensile test shows that the failure takes place because of shear fracture which was away from the nugget due to softening because of thermal effect. [8]

Rajakumar and Balasubramanian (2012) studied the friction stir weld joint made by six different types of aluminium alloy in which out of these one of the two alloys belongs to the 7xxx series alloy which was AA7075 as well as AA7039. The analysis of the microstructure was performed to obtain the range of feasible process parameters around which the weld should be done. Response surface methodology which has empirical relation was used to obtain the optimum process parameters of welding to attain a maximum possible strength. [9]

Rhodes et al (1997) studied the microstructural behavior and mechanical properties of friction stir welding aluminium alloy. He joined plates of AA7075 along with the variable welding speed 5m per minute and visualized how the variation of microstructure takes place of the welding to be done. He founded low dense dislocation and also nugget was recrystallized so as to strength of weld was increased and precipitates was solutionised. [10]

Yan and Reynolds (2009) studied the initial temper effect of base metal (T7451, T62 and W) and also studied the 4 mm thick AA7050 aluminium alloy by varying process parameters along with post weld heat treatment. The result which is to be obtained by initial temper of the base metal increase the mechanical strength and also different mechanical properties of 7075 aluminium alloys. Post weld aging increases the joint strength and also changes the fracture dislocation from heat affected zone to nugget of weld. [11]

V. ADVANTAGE AND DISADVANTAGE OF FSW

➢ **Advantage**

The important advantage of FSW over traditional welding processes is that no melting of the work piece material takes place. Other advantage are,

- Distortion is considerably very low as well as residual stresses in welded zone.
- Higher mechanical properties like ultimate tensile strength, yield strength and hardness.
- Because of non-presence of toxic fumes and harmful radiation causes suitable for environment.
- Safety is improved due to the non-presence of toxic fumes.
- Easily automated on simple milling machines, lower setup costs and less training skill.
- It can be operated in all positions (horizontal, vertical, etc.), because of no weld pool.

➢ **Disadvantage**

- Work piece should be clamp very carefully for the weld to be done correctly.
- Thickness of the surface is reduced marginally during the process because no filler material is used.
- Due to the speed of the tool and axial pressure force acting, there is possibility of breaking of the tip of the tool and the tip stuck in the weld zone.
- When the tool is retrieved back an exit hole is left behind.

Fsw Joint with Hole

VI. APPLICATION OF FSW

The FSW process is suitable for welding plates, pipes and fabrications of complex shape. Applications of the FSW include various industries including a few of the following.

- FSW is mostly used in aircraft industries for welding wings, fuel tanks, aircraft structure and also used in marine industries for structure work.
- Used in marine industries for structure work and railway industry to build a railway tankers.
- Used in automotive industries to weld wheel rims, chassis, fuel tanks and other structure work.
- Recently started using in engine chassis and body frame of automobile in the automotive industry.

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- It is also being used in housing of electric motor and refrigeration panel weld.
- It is extensively used in marine structure and platform where helicopter lands.
- Friction stir welding is also used in electronic industries for the joining of bus bar, aluminium to copper, other electronic equipment and connectors.
- Because of solid state joining process it is also used for welding of fuel tank of space vehicle.

VII. CONCLUSION

It is to be obtained from the survey of the literature that the material transformation, material distribution during weld time, geometry of the tool, optimum process parameters, microstructural behavior and mechanical properties of Friction stir welding of aluminium alloy joints. Simulated model study to be done to obtain a material flow process during weld as well as how heat transfer is to be affected by varying tool geometry and process parameters.

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