Comparison between Friction stir welding & Fusion welding of Aluminium Alloys based on mechanical properties & microstructure: A Review

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Abstract: This study is to investigate the influence of welding parameters on the mechanical properties of Aluminium plates joined by Gas Metal Arc Welding (GMAW) and Gas Tungsten Arc Welding (GTAW) & Friction Stir Welding (FSW). The various welding parameters like welding speed, shielding gas, wire feed rate, current, voltage, power supply, filler wire material, heat input, gas flow rate are affects the mechanical properties of welded joint. This study also analyze the various types of testing methods used for determines the mechanical properties of weld materials and the material characterization can be obtained by the microstructure of different weld materials.

Keywords: Aluminium Alloys, FSW, GMAW, GTAW, Mechanical Properties, Welding Parameters.

I. INTRODUCTION

Aluminium alloys widely used in aerospace, automobile industries, railway vehicles, bridges and high speed ships, because it has light weight and higher strength to weight ratio, corrosion resistance and ductility.

Friction stir welding (FSW) is a solid state joining process that was developed by the TWI, UK in 1991 . FSW is a relatively new and promising welding process that can produce low-cost and high-quality weld joints of heat treatable aluminium alloys. In FSW as a basis a non-consumable HSS tool with a special designed pin and a shoulder is made to plunged in the abutting edges of the plates to be joined to a preset depth and moved along the weld joint. Heat is generated through the frictional contact between the rotating tool shoulder, and abutting material surface.

In TIG welding, an electric arc is formed between consumable tungsten electrode and the workpiece. The arc provides the thermal energy to melt the work pieces as well as the filler if necessary.

Gas metal arc welding (GMAW) is a welding process in which an electric arc forms between a consumable wire electrode and the work piece metal(s), which heats the work piece metal(s), causing them to melt, and join. Along with the wire electrode, a shielding gas feeds through the welding gun, which shields the process from contaminants in the air.

As TIG & MIG is the most widely used process for welding aluminium, so it needs to be compared with emerging welding techniques like FSW to assure best quality welds as far as possible.

II. LITERATURE REVIEW

Balasubramanian V., Ravisankar V. And Madhusudhan Reddy G.[1] studied the high strength aluminium alloy joints produced by gas metal arc welding and gas tungsten arc welding under the effect of continuous current and pulsed current technique. Pure argon used as a shielding gas. The pulsed current gas metal arc weld joints produced high strength values and high joint efficiency than other welded joints. Due to that of fine grains the Base metal and heat affected zone regions produced high hardness values than weld metal. Pulsed current gas tungsten arc weld joints produced high highness values and continuous current gas metal arc weld

joints produced low hardness values. A very fine grain in the welded region was produced by the pulsated current gas metal arc welding.

Lakshminarayanan A.K., Balasubramanian V. And Elangovan K. [2] investigated the AA6061 Aluminium alloy joints mechanical properties welded by gas metal arc welding, gas tungsten arc welding and friction stir welding. Single V joint configuration, pure argon shielding gas and AA4043 filler wire were used for the gas metal arc welding and gas tungsten arc welding. Non consumable high carbon steel tool was used for the friction stir welding. Diamond compound was used for a final polishing. The friction stir weld joints produced the high strength values than GMAW and GTAW. The strength value 34% higher than the GMAW and 15% higher than the GTAW. The base metal and heat

affected zone produced the high hardness values than the weld metal. FSW produced the high hardness value and GMAW produced low hardness value.

Equiaxed uniformly distributed fine grains increased the high tensile properties in the weld region for FSW joints.

Ghazvinloo H.R., Honarbakhsh-Raouf A. And Shadfar N. [3] analysed robotic MIG welding AA6061 fatigue life, impact and bead penetration properties under the effect of welding speed, voltage and current. 2.35 mm and 10mm thickness 60 degree V groove plates were welded by using 1mm diameter ER5356 filler material. The welding parameters welding speed, voltage and current were varied during the process. The increased voltage and current reduced the fatigue life but the welding speed increased the fatigue life. Decreased welding speed and increased current voltage improved the impact energy. Bead penetration mainly influenced and depends on the welding current.

Anjaneya Prasad B. and Prasanna P. [4]

Experimented AA6061 joints welded by Metal Inert Gas (MIG) and Friction Stir Welding (FSW). The FSW was carried out by 3 axis computer numerical controlled milling machine CIMTRIX. semiautomatic welding machine MIG 350 carried out the MIG welding with the welding speed of 110mm per min. FSW showed 10-100 times smaller grains than the MIG welding in the microstructure of the weld joints. MIG welding produced the less tensile strength than FSW. The amount of heat input affected the weld material hardness and the width of hardness was determined by shoulder diameter and heat input. The FSW reduced production cost, pre operations and increased the weld quality.

S. Jannet, P.K. Mathews, R. Raja [5] In this paper, the mechanical properties of welded joints of 6061 T6 and 5083 O aluminium alloy obtained using friction stir welding (FSW) with four rotation speed (450, 560, 710 and 900 rpm) and conventional fusion welding are studied.FSW welds were carried out on a milling machine. The performance of FSW and Fusion welded joints were identified using tensile, hardness and microstructure. Better tensile strength was obtained with FSW welded joints. The width of the heat affected zone of FSW was narrower than Fusion welded joints welded joints. Properties FSW and Fusion Welded processes were also compared with each other to understand the advantages and disadvantages of the processes for welding applications of the Al alloy.

Baiju Sasidharan, Dr. K.P. Narayanan, Prakash.R.S [6] This paper lights on that aspects in the case of high strength low weight aluminium alloy AA2219, which possess low thermal characteristics of plates 300X300mm. Welded joints from two types of welding techniques namely DCSP (Direct current straight polarity) TIG welding and Friction Stir Welding (FSW) have been considered for the present study. These two welding techniques are characterized by their low heat input to the metal while joining. In DCSP TIG welding weld plate and electrodes are connected positive and negative leads of weld transformer respectively with a constant supply of current. Due to the hitting of more number of electrons from electrode on job while welding, joining edges were heated with less heat input which result in a welded joint with good weld strength. FSW is a solid metal joining process where no melting of material is taking place compared to conventional welding techniques. Here a FSW set up has been developed in a conventional vertical milling machine (with a tool geometry of 20mm shoulder diameter, 6.35mm as pin diameter and 5mm as pin length, tool rotation of 1800 rpm, linear traverse of 100mm/min) and obtained good FSW joints. Comparative study on Tensile and Micro structural characteristics of welded joints obtained from DCSP TIGW and FSW has been made. The Ultimate Tensile Strength (UTS) of DCSP TIG welded joint has been found 257.48MPa. The UTS for FSW resulted is 287.9MPa. They are 58.5% and 65.4% compared to the parent metal. Percentage elongation for FSW joint has also been found more than that of parent metal. From the microstructure study it is seen that FSW joints are having very less micro porosities compared to DCSP TIG welded joints. Hence it is inferred that FSW techniques are more suited for the effective joining of alloys like AA2219.

Ashwani Kumar, Shakti Singh Gautam and Alok Kumar[7]In the present work TIG, MIG and FSW welding processes were used to weld aluminium alloy AA6061.FSW performed on vertical milling machine at 60mm/min welding speed, 0.69 kJ/mm heat input, 635 rpm of tool rotational speed, 16mm tool shoulder dia,7mm pin dia, 4.7mm pin length, 20 degree tool tilt angle.

The heat input in case of FSW is less than that of TIG and MIG welding processes. Among these three welding processes, in FSW heat input are 38% less as compared to TIG welding and 51.2% less as compared to MIG welding process. FSW joint efficiency is 19.4% higher as compared to TIG welded joints and 35.5% higher as compared to MIG welded joints. With the help of FSW as comparison to TIG and MIG, nice welds having higher joint efficiency with less heat input.

Amardeep S.N, Sunil Mangshetty[8] In this study, AA7075/ AA6063 aluminium alloy plates of 120×70×5mm have been welded by conventional fusion welding process tungsten inert gas (TIG) welding and friction stir welding (FSW) process. The tool used in FSW process consists of a shoulder with a diameter of 20 mm and a pin with a diameter of 4 mm and a length of 3.5 mm, the optimum tool rotation and welding speeds are selected as 1400rpm and 100 mm min. The

TIG welding process was performed with Magmaweid TAL 4043 filler rod of 3mm dia at 100 amp current , 20V,argon gas shielding at 5 bar pressure.. Taking into consideration the process conditions and requirements, FSW and TIG processes were compared with each other to understand the advantages and disadvantages of the welding processes. Microstructural examination reveals that smaller grain sizes are obtained in the weld centre of FS welded specimens due to recrystallization, where as grain growth has been observed in TIG welded specimen due to severe heat input. The UTM and Vickers hardness test results show that among the two welding methods employed, FSW has yielded the best mechanical properties.

S.Navyashree,V.Sivaramakrishna[9] considered two different welding processes: a conventional tungsten inert gas (TIG) and an innovative solid state welding process known as friction stir welding (FSW) for the joining of commercial aluminium plates of 150X50X6mm of size. In TIG welding heat is produced by an electric arc created between non consumable tungsten electrode and the weld pool by using alternating current. A CNC milling machine is used for friction stir welding (FSW) of aluminium alloy. The machine has used to maximum speed of 1000 rpm; test piece was clamped in the fixture tightly. Initially the rotating pin was inserted into a predrilled hole, which will start up of welding. Processing began at spindle speed at 1000 rpm and travel rate of 18 inch/min. The speed increased to 1200rpm and feed rate to 14 inch/min.

The results indicate that the microstructure of fiction weld is different from the tungsten inert gas welded joint. The weld nugget consists of small grains in friction stir welding and those are found in tungsten inert gas weld. The tensile strength of weld joint in friction stir welding is more instead of tungsten inert gas welding. Hardness test of friction stir welding is more instead of tungsten inert gas where as in parent material also. From the observations in the project it is concluded that:

Smooth surface finish can be obtained by using Friction stir welding with a tool having a smooth pin. The microstructure is studied and observed that the heat affected zone (HAZ) is well fused and free from non metallic defects. Here in the Friction stir welding the breaking point is outside the weld on tensile test whereas in TIG welding the breaking point is exactly on the weld. Here in the hardness test on the weld. Friction stir welding is more better than TIG welding No cracking occurred in the heat affected zone

III. CONCLUSION

The mechanical & metallurgical properties of TIG, MIG & FSW of aluminium alloys are evaluated. This review reveals that the tensile properties of welded joints are influenced by welding process. FSW joints shows comparatively excellent mechanical & metallurgical properties when compared to TIG & MIG joints.FSW is a green and environmentally friendly welding technology because of low energy consumption, no gas emission, and no need for consumable material such as electrodes, filler metals, and shielding gases (normally present in fusion welding processes)

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