Investigation on Friction Stir Welding Of Aluminium AA7075 Alloy and Optimizing the Process Parameters to Obtain Maximum Strength

[1]K. Karthikeyan and [2] L. R. Murasu

[1,2] Asst Professor,Mechanical Emgineering,C.K College of Engineering & Technology

ABSTRACT

In this Work welding of Friction stir welding of aluminium alloy AA 7075 using an FSW machine was successfully completed. The Aluminium alloy is used in marine, Aerospace, Automobile applications. In FSW the downward or forging force was found to be dependent upon the shoulder diameter and rotational speed whereas the longitudinal or welding force on welding speed and pin diameter. The tensile strength of welds was significantly affected by welding speed and shoulder Diameter. The welding speed directly affects the percentage of elongation. The studies shows a fine grains Occurs in the weld nugget zone (WNZ) and Micro structural changes in the thermo mechanically affected zone(TMAZ) were found to be combined and influences of frictional heat and deformation. A maximum Joining efficiency was obtained for welds with good elongation. Microstructure studies show a Coarsening and or dissolving of precipitates in nugget. Furthermore the Void defect is formed in the joint whereas the weld speed or rotational speed is quite high. In these Work different Parameters is taken for Friction stir welding as rotational speed, Welding speed and a constant Value is taken for Shoulder Diameter and Pin Diameter.

Index Terms: Friction stir welding, Microstructure, Tensile Property, Corrosion Resistance.

1. INTRODUCTION

Friction stir welding is a solid state welding process in which relative motion between the tool and work piece produces the heat which makes the material of two edges being joined by plastic atomic diffusion. In these method relies on the direct conversion of mechanical energy to thermal energy to form the weld without the application of heat from conventional source, Welding Parameters, Tool geometry and joint design makes the considerable effect on the material flow pattern and temperature distribution. The tensile strength is higher is obtained in the lower welding speed .It indicates the lower range of welding speed is suitable for Achieving a higher Tensile strength. The base metal is not melted during these welding process the defects that commonly occur in the fusion weld is avoided in addition reduce the heat generation with respect to fusion weld also results in reduction in residual stress in the joints[2].The AA 7075 Aluminium Alloy is high strength Al-Mg alloy with several advantages such as good weldability, high strength, good Mechanical Properties. Furthermore the Thickness of the AA 7075 Aluminium alloy welded plates ranges is 6mm.

The Friction stir welding usually consist of four regions they are(a) Un affected base metal (b) Heat affected zone(HAZ) (c) Thermo mechanically affected zone(TMAZ) and (d) Friction stir processed zone (FSP). The Heat Affected zone(HAZ) lies close to the weld center. the material has experienced a thermal cycle so modifications in the mechanical properties and in microstructure are noticed however no plastic deformation occur in these zone the Thermo mechanically affected zone (TMAZ) has been plastically deformed by the friction stir welding tool and heat from the process also exerts some influence on the material the weld nugget a recrystallized area in (TMAZ) in Hence in these Paper an attempt was made to study the mechanical Properties of

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Aluminium alloy AA 7075 using Friction stir method by keeping different process parameters as Tool rotational speed, Welding speed and a constant tool parameters as Pin diameter, Shoulder diameter.

2. EXPERIMENTAL PROCEDURE

The Specimens of the size of 100mm x 50mm x 6mm were machined from Aluminium alloy AA 7075 . The two plates of AA 7075 Aluminium alloy were Friction stir welded using a Conical tool profile made of Molybdenum base high speed steel. It Comprises of 18mm Shoulder diameter, 6mm pin diameter and 5.8mm pin length under the process parameters of rotational spindle speed of 900,1000,1200,1400,1600 rpm, and the welding speed of 20,30,30,40,50 mm/min and 1,2,3,4,5 KN axial force is applied in the butt Configuration by using FSW. The Experimental set up is shown in Figure (a)The rotation of tool resulted in stirring and mixing of material around the rotating pin and the liner movement of tool moved the stirred material from the front to the back of the pin and finished the welding process. The insertion depth of the pin into the work piece was associated with the pin height. The tool shoulder contacting the work piece surface depends on the insertion depth of the pin, which results in generation of welds with inner channel and surface groove.

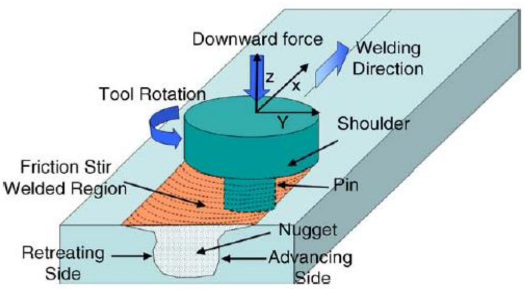

Figure-1 : Schematic Diagram of Friction stir welding Joint

Figure-2 ; Photo of FSW Machine

Figure-3 : Photo of Processing Joint

The selected parameters is used to weld the joint of aluminium alloy AA 7075. In these work we use a different Process parameters welding speed, Rotational speed and a constant tool parameters as, Pin Diameter, Shoulder Diameter is maintain and in these work from these parameters we obtain a five pieces of aluminium AA 7075.

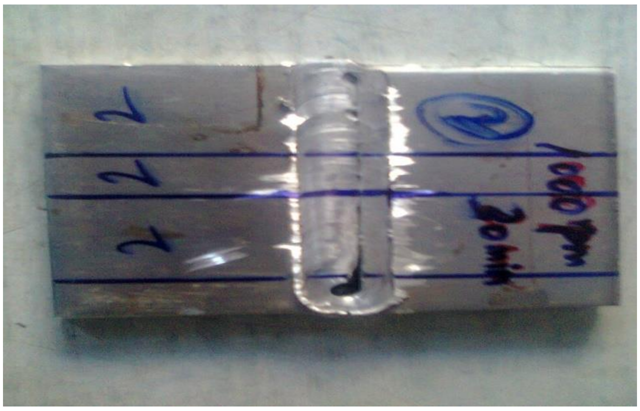

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Figure-4: Friction stir welding of Aluminium 7075

The tensile strength was carried out in ASTM Standard the Friction stir welding (FSW) joint plates were sawed into the dimension of 100mm * 50mm the tensile strength were carried out in universal testing machine(UTM). The method and the microstructure was carried out in Scanning electron Microscope (SEM) the Chemical Composition of Aluminium alloy 7075 are given in the table and a Tool dimensions are shown in the table.

Table-1 : Percentage of chemical composition of Aluminium 5086

Mg	Si	Fe	Cu	Mn	Ti	Cr	Zn	Al	Ca
2.81	064	0.22	0.04	0.87	0.050	0.72	0.28	95.87	0.14

Table-2 : Friction stir welding Parameters and Tool Dimension

Parameters	Values
Rotational Speed(rpm)	900,1000,1200,1400,1600 rpm
Welding Speed(mm/min)	20,30,30,40,50 mm/min
Tilt Angle(˚c)	1,2,3,4,5 Degree
Tool Material	High Speed Tool steel(M2)
Tool Pin Profile	Conical
Pin Diameter	6mm
Shoulder Diameter(mm)	18mm
Axial Force	1,2,3,4,5,

2.1 MATERIAL PROPERTIES

The chemical composition of M2 Tool Steel contains Chromium(Cr) - 4%, Carbon -0.95%, Molybdenum -5%, Tungsten -6%, Vanadium -2% , Aluminium – Remaining. The Molybdenum based high speed steel in Tungsten molybdenum series. It has High Wear resistance, Hardness and completed with high abrasion resistance.

Molybdenum(M2) high speed Tool Steel have the Following Properties as :

Table-3: M2 Tool steel Properties

Material Properties	**Value**
Elastic Modulus(Gpa)	210
Poisson ratio	0.30
CompressiveYield strength(Mpa)	3250
Thermal conductivity(W/m K)	130
Coefficient of thermal expansion(C˚)	$24.78*10^{-6}$
Density(kg/m^3)	8.16
Specific heat capacity(J/Kg)	960
Melting PointTemperature(C˚)	4680

Molybendum steels have a similar performance compare tungsten speed steel M2 Tools are tempered at 1890˚C and

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Annealing at 2592˚C and finally they are hardened and Quenching respectively.

Figure-5: M2 Tool Steel (Molybdenum base)

2.3 MECHANICAL TESTS

Each specimen are taken and tested for mechanical Properties like Tensile Test, and Microstructure test

- 1. Micro structural Characteristics

The Typical cross section of defect free weld joint at the rotational speed of 1600 rpm and the welding speed of 50mm/min and the (Fig4) represents the grain structure extracted from the WNZ, TMAZ, HAZ, and BM at the weld mid plane . The RS and AS represents the retreating side and advancing side respectively and they compared with rolled Coarsened grains in the BM (Fig10) the microstructure in the weld nugget zone(WNZ) are characterized by fine and equaixed grain structure owing to dynamic re crystallization during friction stir welding in the (WNZ) the grain size is varies significantly in thickness direction. the grain size tends to be largest in the middle part and smallest in the lower part. The upper part is mainly fractionized and stirred by the tool shoulder While the middle and lower part are only fractionized and stirred by tool pin,

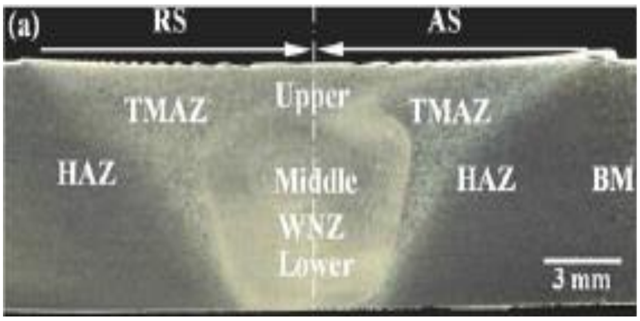

Figure-6: Microstructure of FSW Joint

The heat input to the upper part is higher compare to lower and middle parts, The plastic deformation is strongest in the upper part while the middle deformation and heat dissipation is lower than that in upper and lower parts the lowest part has lowest Heat input and the highest heat output thus the grain size is smallest in the (WNZ) and no plastic Deformation occur in the heat affected zone(HAZ) it exhibits smaller grain structure.

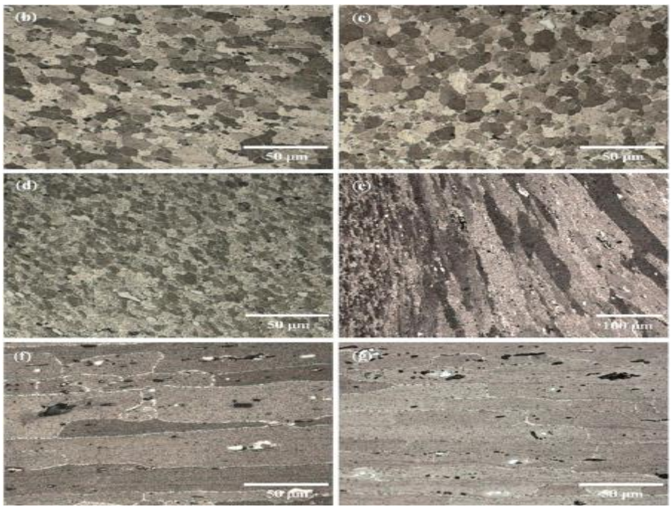

Figure-7: b, c ,d(Upper, middle, lower Part of WNZ) ,e(TMAZ) ,f (HAZ), g (BM)

2. Welding Defects

At the rotation speed of 1200 rpm Void defect is formed in the weld nugget zone(WAZ)/Thermo mechanically affected zone(TMAZ) border on the advancing side(AS) in these case the material is not plasticized to the level that can be transformed from the back surface of the tool pin to the AS(Advancing side) on the other hand rotational speed of 1000rpm is applied for the welding speed of 30mm/min void defect is produced in the (WNZ) Weld nugget zone.

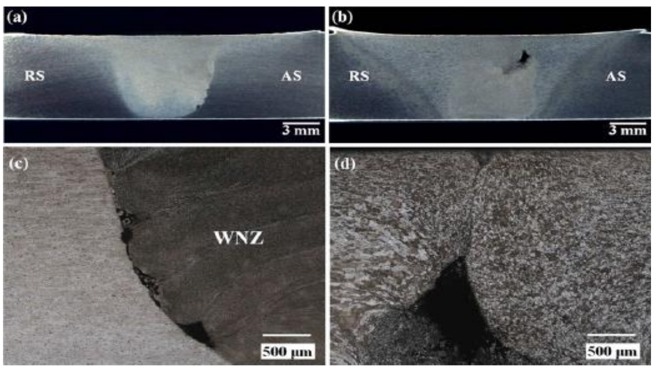

Figure-8 : Welding defects in the joint welded at different welding parameters, a. Rotational speed 1000rpm at 30mm/min, b. Rotational speed of 1200 rpm at 30mm/min, c, d Enlarged view of welding defects

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The formation of void defect is occurred during the high rotational speed in the FSW of Aluminium AA 7075.The heat input increase the fluidity of the material and thus makes the turbulence flow in the (WNZ). The strain and microstructure discontinuities arising from the turbulence flow finally cause the void defect. Thermo-mechanically affected zone (TMAZ)

Unique to the FSW Process is the creation of transition zone- Thermo-mechanically affected zone(TMAZ) between the parent material and nugget zone TMAZ shows the both temperature and deformation occurs in the friction stir method They are characterized by a highly deformed structure and the parent material elongated grains were deformed in the upward flowing around the nugget zone, and TMAZ underwent plastic deformation, recrystallization does not occur in these zone due to insufficient deformation strain, it contains high density of sub boundaries

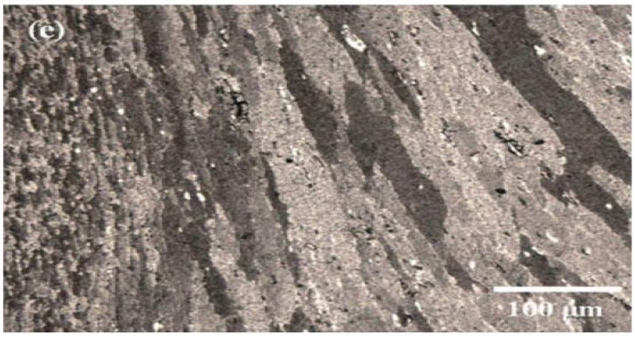

Figure-9: Microstructure of Thermo-mechanically affected zone in aluminium 7075

3.Tensile Properties

The Tensile Properties of joints as a function of rotation speed and welding speed it can be seen that the tensile strength of the joint is increased with increasing the rotation speed from 900rpm to 1600rpm for a varying welding speed of 20,30,40,50 mm/min respectively increasing the rotation speed would extend the shoulder dominated zone over the plate thickness however the material in the shoulder dominated zone is softer and easier to be stirred extending these zone thickness enhance the stirring and consequently improves the tensile strength.

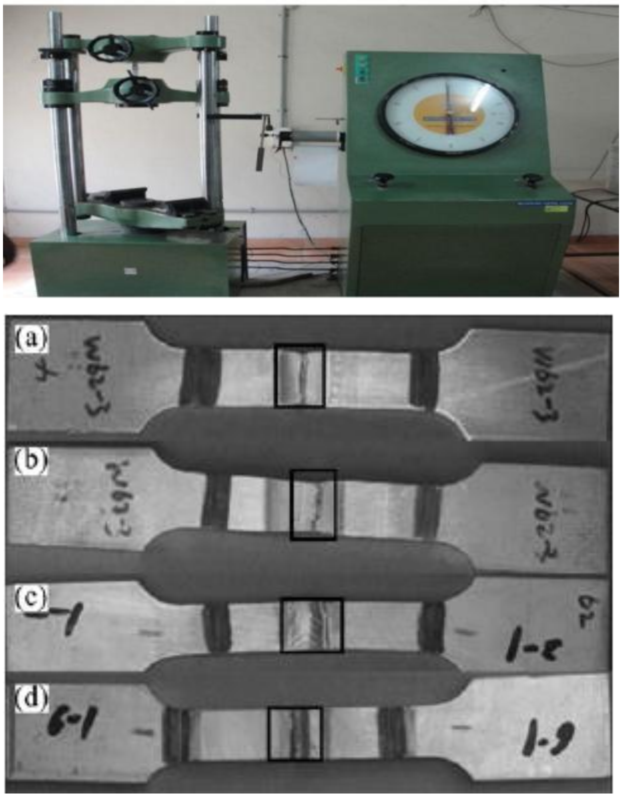

Figure -10: a. Universal Testing Machine
b. Photos of welded joints for tensile samples

Table-4: Tensile Properties of Aluminium 5086

S. No	Tool Rotational Speed (rpm)	Tool Travel Speed (mm/min)	UTS (MPa)	YS (MPa)	Elongation (%)
1	900	20	164.5	78.4	18.7
2	1000	30	155	66.8	16.8
3	1200	30	148	74.8	14.8
4	1400	40	160	72	13
5	1500	50	162	64	11

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Using a bar chart and it represents the Rotational speed, Welding speed, Ultimate tensile strength, Yield strength, and, Elongation for the tensile properties of Aluminium 5086 weld joint.

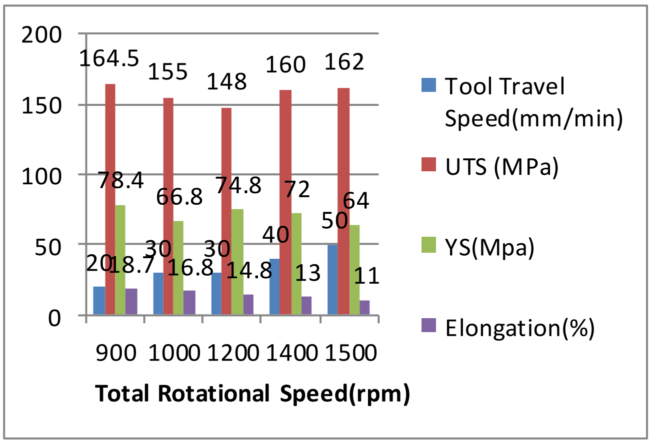

Figure-11: Tensile Properties of Weld joint

4. Corrosion Properties

The susceptibility of Aluminium and Magnesium combination alloys can be determined by using (Acid salt spray Test Test) , It consist on the immersion of the tested specimen in concentrated HNO at 30˚c for 24 hours and measuring the mass loss.In order to obtain SSC(Stress corrosion cracking) suspectability, slow strain rate Testing is recommended to be used and it is used as a ASTM standard. Materials are suspected to environmentally assisted cracking it consist of slow strain rate tension test in the corrosive Environment. The aluminium AA 7075 Al –Mg alloys with less than 3% Mg for marine application is related to the control of precipitation of β phase which could be highly sensitive for sea water attack, Discontinuous of phase precipitation and equiaxed grain structure reduce the Suspect ability to grain boundary or intergranular corrosion and exfoliation respectively.

The Corrosion behaviour of FSW Joint of AA 7075 Aluminium alloy was investigated by acid salt spray and investigate macroscopical corrosion features and the prior corrosion location is the thermo mechanically affected zone(TMAZ) Which locate between the base metal and welded seam.

The corrosion types are mainly composed of pitting, intergranular, Exfoliation corrosion.

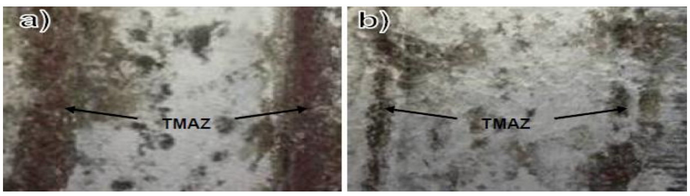

Figure-12: Macroscopical Corrosion features of top surface of weld joint (24hours)

3. CONCLUSION

FSW of aluminium alloy AA 7075 was carried out in investigation and the conclusion of significance are summarized as follows:

In (WNZ) Weld nugget zone of all the joints the grains in the middle part posses larger size than those in upper and lower parts the rotational speed or welding speed increase up to a high value void defect is formed. In these case increase the rotational speed for fixed welding speed or increasing welding speed for a fixed rotation speed, the tensile property is increased first and decrease due to the occurrence of weld defect. The maximum tensile strength is achieved in 900rpm of rotational speed and 20mm/min of welding speed.

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