

Experimental Investigation of Friction Stir Welding of Dissimilar Aluminium Alloys AA6061-AA7075

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Abstract—The brief introduction to the work and the FSW scope in joining of similar and dissimilar aluminum alloys. Discusses the relevant literature and the required background. Friction stir welding for joining AA6061-AA7075 dissimilar alloys along with the mechanical properties like ductility, hardness is discussed. Depending on the relevant summed up literature the objective of the present work at the end of this chapter is highlighted. The discussion of problem formulation is done on the basis of the observed shortcomings in the literature. To present the experimental methodologies, and the techniques and instruments adopted to perform the experiments. The results of the experiments of FSW, under different processing conditions are shown. The micro structural evolution obtained after FSW joints and the tensile and hardness properties developed are discussed. Provides conclusions in a detailed form arising out of the work.

Index Terms—Friction Stir Welding, Process Parameters, Microstructure, Mechanical Properties

I. INTRODUCTION

Aerospace, automobile industries require the manufacture of critical components where in aluminum can be used extensively as it can exhibit high strength to weight ratio. Joining of similar aluminum alloys through FSW is already a proven technique in recent times. The joint strength observed from so many studies reveals that FSW is a far better process for joining materials with improved mechanical properties when compared to conventional welding techniques. However the joining of dissimilar soft combinations of aluminum alloys is quite

challenging and the advantages in joining these types of materials are enormous. The properties of both the joining materials can be utilized and thereby results in a high strength weld joint.

The solid-state joining process Friction stir welding (FSW) operates with a non-consumable tool to join two work pieces without melting the base material. Cylindrical revolving tool with a small profiled pin is inserting into a butt joint between two clamp work pieces, till the larger diameter shoulder comes in make contact with the work piece surface. The pin length will be kept shorter than the depth of weld required with shoulder rubbing the work piece surface. After few seconds of tool pin plunge the tool will move along the butt weld center line with a predetermined speed to complete the welded joint.

The heat generated due to the friction between the wear resistant rotating tool and the work piece material, leads to a soften region near the FSW tool due to stirring action without melting the metal. The tool is directed to traverse on the joint line and automatically intermixes the two materials and forges the softened metal in the cavity by the mechanical pressure. This results in a severe deformation of the material in a solid state and the grain refinement happens due to dynamic recrystallization. A quantity of forces will act on the tool during welding and to retain the position of the tool at or below the material surface a downwards force is always necessary which can affect the properties of welded joints.

FSW solid-state nature has several benefits over fusion attachment strategies as issues related to cooling, Porosity, substance distribution, hardening cracking

and liquidation cracking problems don't arise throughout FSW. In general, FSW has been found to provide an occasional concentration of defects and is extremely tolerant of variations in parameters and materials.

The present study aims primarily at the understanding of the mechanical behavior of different welded joints under different processing conditions and to examine the microstructure variations in nugget zone, thermo-mechanically affected zone/ heat affected zone (TMAZ/HAZ).

II. LITERATURE REVIEW

In this chapter the literature regarding the dissimilar joining of materials are examined in detail. The work carried out by different researchers in the area of joining similar, dissimilar aluminium alloys was studied thoroughly and some of the relevant papers are highlighted below.

Govind Reddy, et. al., [2] worked on method Constraint optimizing for Friction Stir welding of dissimilar Al Alloys. In this effort the results of revolving speed and attachment velocity on the durability of dissimilar FSW AA2024-AA7075 joints are examined. Tensile force of the FSW joints with varied tool motion speed and crossways speeds are measured through an experiment. A numerical model for strength of the joints is developed. The model is employed to review the result of rotation speed and welding velocity on strength of the joints.

Malarvizhietet, et. al., [3] have shown the effects of tool diameter to plate depth relation (D/T) on stir zone creation and tensile property of friction stir welded dissimilar joints of AA6061-AZ31 alloys. The macrostructure, microstructure and tensile property of the dissimilar AA6061 metal and AZ31 Magnesium alloys are studied. The shoulder diameter of 21 mm exhibited superior tensile properties compare to its counterpart.

Hironoriet, et. al., [4] made a study on best Handling and instrument Controls for Three-D Friction Stir Welding. The FSW instrument control on seams mechanical properties was examined. However FSW is wide practical to linear joints, it isn't potential for axis Friction Stir Welding equipment to stay up all FSW constraints in optimal circumstances throughout

three dimensional (3D) attachments. Such three D FSW joints should be formed permitting to an order of importance for FSW parameters. Butt joints with rectangular modification within the welding direction on a curvilinear plane were welded persecution completely diverse 3 tool-control ways, that adjustment varied welding parameters.

Masoud Jabbari, et. al., [5] conducted a trial to seek out Optimum Rotation Speed for the Friction Stir welding of Pure Copper. The study showed copper plates with the depth of 4 mm at intermissions and steady traverse speed of 5 mm/min and 5 absolutely different revolution speeds. Increased rotation speed showed the rise of grain size within the nugget zone. Rotational speed, transverse speed and D/d ratio were 700 rpm, 15 mm/min and 3 correspondingly for the optimum level. Threaded tool pin profile with cylindrical shape showed the best results. The contribution of D/d ratio is 60% of the overall contribution. Al-Cu alloy AA2219-T87 and Al-Mg alloy AA5083-H321 plate joining was also carried by using FSW.

DhananjayuluAvula, et. al., [6] has made an effort to find the result of FSW on Micro structural and Mechanical Properties of Copper Alloy. Microstructure, hardness and tensile property were evaluated. The normal hardness at the upper portion was higher than bottom portion in the stir zone. Diverse microstructure area was exposed by optical microscopy and SEM. The stirred zone (SZ) displayed primary two phases.

Colliganetet, et. al., [7] made an analysis on physical flow during FSW of aluminum. To date, the bulk of analysis has targeted in developing the tools and procedures for creating reliable welds and on characterizing the properties of welds. However, little work is done regarding sensible flow behavior throughout welding. The aim of this study was to document the movement of material stirred throughout friction stir welding and as a way of developing an abstract model of the deformation method. In this paper new method for visualizing objects flow patterns in friction stir welds are presented. Material movement in welds of 6061 and 7075 Al were studied at various regions of the weld center line and the results assisted in developing a physical flow model.

Some of the studies carried out by conventional techniques are also studied in order to understand the microstructure behaviour and the strength properties of the welded joints. Though some of the fusion welding methods are good but the disadvantages found due to the inherent defects affect in achieving the maximum weld strength.

Sivashanmugam M, et. al., [8] operated on metal composite 7075 by the technique of GTAW. The strength parameters considered for investigation are hardness and impact. The strength got slashed with relation to parental metal.

Abbasi K, et. al., [9] has deliberated on welding parameter like feed rate and arc voltage. The argon carbon oxide mixture used is in the range of 7 to 230 bars. The study helped to relate the feed rate and the arc voltage and the effect in properties change of weld joint.

Oladele I. O., et.al., [10] worked on 6063Al for microscopic investigation of MIG welding. The effect of the parameters current and voltage on microstructure, strength, and toughness and impression strength were studied. This study revealed the role of current and voltage in achieving the desired properties in the welded joint.

Rajesh P Verna, et. al., [11] showed the effect of metal arc and gas welding on Aluminum 6061 –T6 and 5083-0 Aluminum alloy. The work piece selected for welding was 250 x 1000 x 8 mm. Metal arc joined samples failed at weld area and gas welding showed failure more of at heat affected zone.

Anjanaya Prasad B, et. al., [12] experimented to derive the mechanical properties on AA6061 by MIG and FSW methods. MIG showed more consistency because of the good solubility in the liquefied pool. The MIG designed by columnar crystalline construction is totally diverse in appearance to Friction Stir Welding, whereas Friction Stir Welding samples provided a well microstructure by the side of nugget region. FSW displayed a stronger joint than MIG.

Nabeel Gharaibh, et. al., [13] conducted studies on the profile of the tool pin and FSW parameters for the material AA6061 and investigated the effect on the microstructure and mechanical properties. Two AA-6061 aluminium plate with dimension 300×150×6mm. were selected for FSW. Hexagonal, square and

triangular pin profiles selected for FSW with tool rotational speeds of 560, 700, 900, 1120, and 1300 rpm and traverse speed of 0.5, 1, 1.5, 2 and 2.5 mm/sec. The FSW for all the parameters was carried out with a single pass. Mechanical characterization, macroscopic and microstructural analysis were performed. The images of the microstructure were captured from the stir zone. Hexagonal tool pin shape showed better grain refinement and also a higher hardness value compared to the other pin profiles. However the square pin profile showed higher ultimate strength.

Sanjay Reddy K Hudgikar, et. al., [14] carried out FSW of AA6061 using different pin profiles diamond, cylindrical, conical shaped pin. Plate size of 200×75×12 mm was used for welding with a rotating tool made of hardened tool steel. A thorough study was carried out in order to study the tool failure with the help of fish bone diagram that can help in analyzing the root causes. By adopting the above method the tool geometry modification with lesser wear was possible which resulted in a optimum parameter of rpm 1200 rpm and travel speed 0.03mm/sec. For all the process parameters, conical threaded pin showed better results with enhanced properties.

Kush P Mehta, et. al., [15] the main intention of the research is to study the formation of defects by using different pin profiles in dissimilar FSW. Aluminum plate and copper plate were joined by FSW concept, a total of nine tool pin profiles were adopted. The processing parameters were kept constant for all the welds developed by the triangular, square, hexagonal and cylindrical pin tool profile shapes. By visual inspection, and macrostructural investigation defects of samples were investigated. Also microstructural analysis and scanning electron microscopy were conducted. The polygonal shapes showed detachment of copper particles from the base metal and were large and irregular. Triangular pin profile showed more irregularities. However the cylindrical pin profile showed defect free macro joint.

Satheeshkumar K., et. al., [16] in this investigation the welding was done at constant load with the help of depth penetration of the tool along the welded joint. The FSW was carried on two aluminum AA6063 plates of 100x50x6 mm. The major focus of this work was to determine the influence of tool Pin Profile on the Mechanical Properties of FSW aluminum alloy.

The tool pin geometry of hexagon and square shape with a constant rotational speed 1500 rpm, transverse speed and axial force of 5 KN were applied. A better material mixing without any defects in the nugget zone was seen in case of hexagonal tool pin profile and also exhibited good mechanical properties.

Khorsid A.M., et. al., [17] in this study AA6061 plates were cold rolled and reduced to the size of 100×6.5 mm and FSW was carried to investigate the mechanical and metallurgical properties. The probe selected was a steel cone pin and the rotational speed selected were 720, 910, 110 and 1400 rpm with a traverse speed 16, 20 and 31.5 mm/min respectively. Optical and scanning electron microscope were used for metallurgical examination. Hardness is measured using Vickers hardness testing equipment. The Vickers hardness was measured at the transverse cross sections with 100 kgf of load for 10 s. Higher joint efficiencies were observed relative to conventional welding techniques. Microstructure analysis was carried out grinding the sample and then polished to mirror surface finish, washed and dried and then etched for microstructure.

Lingraju Dumpala, et. al., [18] conducted the effect of pin tool profile and welding speed on AA6061 alloy joints produced by FSW. Rectangular plates of 100×50 mm dimension are used for welding. Rotational speeds 760, 1130 and 1340 rpm, traverse speed of 11 and 25 mm/min were adopted for welding. Two different tool pin profiles of 3 slots horizontal and 6 slots vertical threaded cylindrical tool were used in this study. Tool material is high chromium alloy steel. Microstructure was measured from Meltzer metallurgical microscope. Emery papers of grades 120, 220, 320, 400 were used for sample preparation. Higher ductility is observed at lower welding speed. Finer grain size was observed by the horizontal slotted pin which resulted by the better stirring of material at welding zone. Lower welding speed showed higher strength and ductility with a fine grain structure.

Prince Saini, et. al., [19] the experimental investigation was studied to analyze the hardness of FSW of AA6061 aluminium pieces. A total number of eighteen rectangular work pieces with dimension 100×50×6 mm were selected. The operating parameters selected for single pass welding are, speed of tool rotation 1950, 3080 and 4600 rpm, with traverse

speed of 20, 25 and 30 mm/min with a cylindrical tool. The specimens are tested for tensile and hardness testing. Hardness was evaluated by Knoop hardness tester and Rockwell hardness tester. Rockwell hardness maximum number was 55 at speed 3080 rpm with feed rate of 30mm/sec. Maximum Brinell hardness number obtained at speed 3080 rpm was 135 with feed rate of 30 mm/sec. The weld joint showed higher hardness number for both Brinell and Rockwell hardness is at 3080 rpm at feed rate of 30mm/sec.

Rohithkumar, et. al., [20] recently have investigated friction stir welded 6061 aluminium alloys. Tool pin with diameter of 7mm and shoulder diameter 20mm is used for FSW. The plate dimensions 200×50×6 mm are used for FSW and the welding speed is in range of 200-400 mm/min and the rotational speed range 355-560 rpm. The maximum joint efficiency achieved is 83.93%. The ultimate tensile strength is directly proportional to the welding speed. At higher welding speed ultimate tensile strength of welds are comparable to those of the base metal.

Padmanaban R., et. al., [21] in this work AA2024-AA7075 FSW joints are investigated to study the effect of tool rotational speed (TRS) and welding speed on the tensile strength of dissimilar materials. The plate size 150×60×6 mm is held in a fixture prepared of mild steel with thickness 20 mm. The tool with a shoulder diameter of 17.5 mm, pin diameter of 5 mm and height of 4.65 mm is used. Tool pin is cylindrical threaded tool made of high speed steel. The pin is plunged to a prearranged depth of 4.7 mm. The heat generated is not sufficient at low TRS; thereby the softening of the material becomes difficult and hence results in improper mixing of material. Low tensile strength was seen due to lower TRS. However between 900 rpm to 1100 rpm TRS better material flow and mixing of the material was observed. But above TRS 1100 rpm produced spark and tunnel defect due to high speed magnificent effect of the pin. Around 1050 rpm TRS maximum tensile strength was exhibited. The problem with the low welding speed is, it leads to the weaker joints due to the prolonged exposure of the work pieces to heat and magnificent of the tool results in the formation of excessive flash defect. Irrespective of TRS, tensile strength of the joint increased with the increase in welding speed approximately up to 15 mm/min, further increase in welding speed resulted in reduced tensile strength. From the above study they concluded to facilitate the

tensile strength would be close to to the maximum when the TRS and welding speed are within 1075 rpm-1125 rpm and 13 mm/min -15 mm/min respectively.

Rajkumar.V, et. al., [22] in this investigation two dissimilar materials AA5052-AA6061 were friction stir welded and the role of tool design and welding parameters were evaluated. Cylindrical threaded tool pin ready of AISI H13 tool steel is used in this study. The welding was done at a tool rotation speed of 710 rpm and traverse speeds are 28 mm/min and 20 mm/min. Plates of size 100×50 mm was selected with AA5052 on advancing side and AA6061 on retreating side. Microstructure was revealed with the etching of the samples by using Keller's reagent (150 ml H₂O + 3 ml of nitric acid, ml of HCL and hydrofluoric acid). The mechanical and metallurgical properties correlation showed that the sample welded at lower feed rate showed better ductility. The indentations for hardness were made for every 0.5 mm to a length of 30 mm across the weld with a diameter 20 mm, shoulder diameter 15 mm and cylindrical pin diameter 5 mm. The study showed that at a constant welding speed, the hardness and tensile values increases in the as the rotational speed and axial load increases. Higher weld speed results in poor heat generation, due to poor heat generation faster cooling occurs and lower metallurgical transformation results in lower strength

Ramrajuramgopalvarma, et. al., [23] in this study the FSW joint is made between AA5083-AA6061 dissimilar alloys. The rotational speed of 1000 rpm and 1600 rpm along with a traverse speed of 40 mm/min and 160 mm/min with vertical load of 2.5 kN and 3.5 kN was used for FSW. High carbon steel tool material was used with a diameter 20 mm, shoulder diameter 15 mm, and cylindrical pin diameter 5 mm. In this experiment carried out when weld speed constant axial load increases.

Bosneag A, et. al., [24] in this study the FSW was carried on three different materials AA2024, AA6061 and AA7075 and welded one above the other. The plate dimensions selected were of 2 mm thickness and 140×250 mm. The upper plate AA6061 is at the top, the middle plate AA7075 and lower plate is A2024. The tool pin used is cylindrical with threaded M6 and material is of sintered tungsten carbide. Rotational speed selected are 600 and 1400 rpm and welding

speed 70 mm/min. Through welded region the vertical force, temperature generated, micro hardness and roughness analysis were carried out. The difference in temperature generated between two rotational speeds was roughly around 500°C. The vertical force decreased with the increase in rotational speed. The roughness is lesser at lower rotational speed.

Maharajan S, et. al., [25] compared the mechanical properties of fusion welding and frictional stir welding of AA6063 plate. The plates to be welded are of size 100×70 mm and 6.3 mm thickness. The FSW machine with a motor capacity 15 HP, load 25 KN and rotational speed 300 rpm is used to develop a FSW joint. Cylindrical pin profile with tool material die-hard steel is used. The desired operating conditions for FSW are rotational speed 800 rpm and traverse speed 20 mm/min, the axial force is 9.5 KN. The AA6063 aluminium welded plates are joined by metal inert gas arc welding and friction stir welding process. The mechanical properties in terms of tensile strength and Rockwell hardness were far better in the FSW 6063 plates than metal inert arc gas welded AA6063 plate.

Ilangovan M, et. al., [26] in this study the effect of several tool pin profiles were investigated for dissimilar FSW of AA6061 and AA5086 alloys. Further the pin profile role on the development of microstructure and mechanical properties were also carried out. The size of the welded plate is 150×150×6 mm. The rotational speed selected was in the range 600-1200 rpm and welding speed of 10-40 mm/min. Straight cylindrical, threaded cylindrical and tapered cylindrical profiles were used for FSW. Microstructure, hardness and tensile strength were evaluated. The hardness in the welded joints increased due to fine grains and intermetallic in the nugget zone. The flow of the material was better in the threaded pin profile and generated defect free nugget zone. Threaded pin profile compared to tapered pin profile showed finer and uniformly distributed particles.

N T Kumbhar, et. al., [27] dissimilar AA5052-AA6061 was FSWed in this study. High speed steel of commercial grade is used as tool with pin length 4.8mm. The plates for welding opted were of the size 300×50×5 mm. For all welding trials the tool tilt was kept constant at 30. The rotational speed 1120 and 1400 rpm are used for several FSW trials at different traverse speeds ranging from 60 mm/min, 80 mm/min

and 100 mm/min. In the nugget zone there was no rigorous mixing of both materials and an abrupt change was observed in the micro hardness across the interface of nugget. However the mechanical properties were good.

The above literature review shows the importance of friction stir welding process to get the required optimized outcomes like better weld ability, and good mechanical properties. Hence the purpose of this work is to characterize the overall friction stir welding process by using experimental methodology for dissimilar aluminum alloys. In this work AA7075-AA6061 were joined by dissimilar FSW. In this regard a thorough study is tried in this study here to find the suitable operating parameters for FSW in order to develop a stronger welded joint of different materials/alloys economically that can be useful for aerospace applications.

Principle of Friction Stir Welding

Frictions stir welding (FSW)

Friction Stir welding (FSW) in the year 1991, a new thought of welding method was developed at Cambridge, by the welding Institute (TWI). The FSW is basically a solid-state joining method where an external tool is employed to join the two metals of similar or dissimilar alloys. Heat is generated between the tool and the metal pieces joint as the tool dips into the weld surface and thereby results in a softened region around the friction stir welding tool. The two parts of metal to be joined automatically gets intermixed at the position of the joint, and the soft metal gets settled in the weld line by mechanical pressure. The schematic representation of the FSW is as shown in the Fig.1.

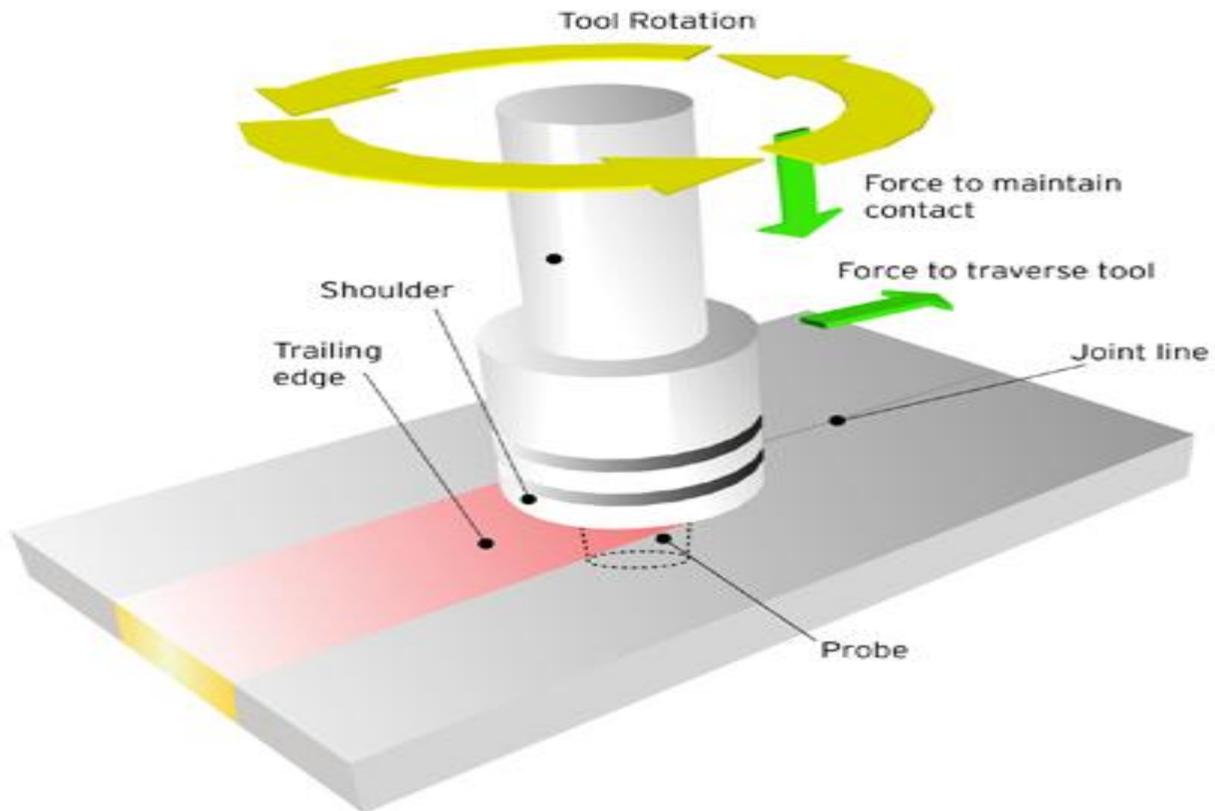


Fig.1. Friction stir welding equipment [1]

The FSW machine used is normally a vertical milling machine shown in figure 4.2 with 7.5 HP motor capacity. The tool is supported by using suitable collates on a vertical arbor. The horizontal bed supports the aluminum plates to be joined with the

clamps of zero root gaps. To restrict the plate movements during welding, the test pieces were firmly clamped so that under both plunging and translational forces of FSW tool, no deviation should occur from the weld center line during the tool movement from

one end to the other end. The tool parameters like rotational speed and translational speed have to be set prior to each run of the tool. The plunging will be stopped as the shoulder comes in contact with the work surface, the bed carrying the work piece will move from one point to the other starts. The tool could be tilt by an angle between 0 – 5°C and the maximum speed of the spindle was 3000 rpm, the traverse speed is 3000 mm/min.



Fig. 2. FSW experimental setup

Friction Stir Welding can be done also in 3-Axis or 5-axis setup. Friction Stir Welding of AA6061 and AA7075 were done with a vertical FSW setup. Aluminum 7075 was selected as advancing side and Aluminum 6061 as retreating side of two abutting metal plates for the selected tool and welding parameters.

Materials and Alloys Welded by FSW

Table 1. Material and Welding Parameters selected for FSW

Sl. No.	Material	Transverse speed (mm/min)	Rotation Speed (RPM)
1	AA6061+AA7075	25	1000
2	AA6061+AA7075	50	1000
3	AA6061+AA7075	25	1500
4	AA6061+AA7075	50	1500

Friction stir welded joints under different processing parameters

The FSW plates processed below different processing situation are shown in the figure 4.4-4.7. Aluminum 7075 was selected as advancing side and Aluminum 6061 as retreating side of two abutting metal plates for the selected tool and welding parameters.



Fig. 3. FSW joint with a processing parameter of (a) rotational speed 1000 rpm, traverse speed 25 mm/min (b) 1000 rpm, 50 mm/min (c) 1500 rpm, 25 mm/min (d) 1500 rpm, 50 mm/min

Micro structural Evolution

Material characterization of FSW samples using SEM Nugget zone micro structure of AA6061- AA7075, under the rotational speed 1000 rpm and traverse speed of 25 mm/min

The Fig.4. Shows the macrostructure of the nugget zone of the FSW joint AA 6061 and AA7075 across the welded section, also the microstructure in Fig. 4. Of the AA6061 retreating side and AA7075 advancing side of the nugget. The grain refinement can be clearly observed in the nugget zone. The images are captured using scanning electron microscope, with the applied voltage 15 KV and working distance of 10.5 mm with 2000X magnification. The grain refinement is mainly appropriate to dynamic recrystallization and the average grain size in the nugget zone is found to be more in the advancing side AA7075 and lesser on the retreating side AA6061 as the peak temperatures generated are higher at the advancing side than the retreating side. The intermixing of the material in the welded joint of AA6061-AA7075 is clearly visible in the Fig.4. across the nugget. This clearly demonstrates the homogeneity of the welded joint along the complete thickness of the weld. There were no defects seen in the welded joint. The nugget zone has also exhibited complete equiaxed grains on together the advancing and retreating side and no grain coarsening is observed in the nugget zone.

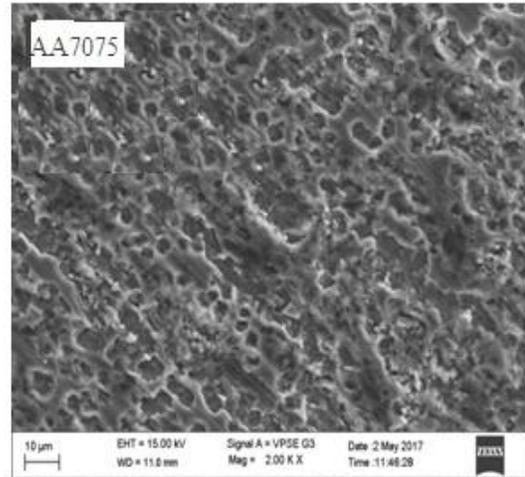


Fig.4. (a) showing the macrostructure of the nugget zone at the intersection of AA6061 -AA7075 weld center line at revolving speed 1000 rpm and cross speed 25 mm/min. (b) showing the microstructure at the intersection of AA6061(retreating side) - AA7075 (advancing side) FSW joint nugget zone at rotational speed 1000 rpm and traverse speed 25 mm/min.

Mechanical Properties of FSW Joints

Evaluation of hardness for FSW welded samples

The hardness of the dissimilar AA6061-AA7075 FSW samples under different processing conditions was measured at different locations of the nugget zone, thermo mechanically affected zone, and heat affected zone and the base metal. The location of hardness of different zones from the weld center line is shown on the horizontal axis and the vertical axis represents the hardness value.

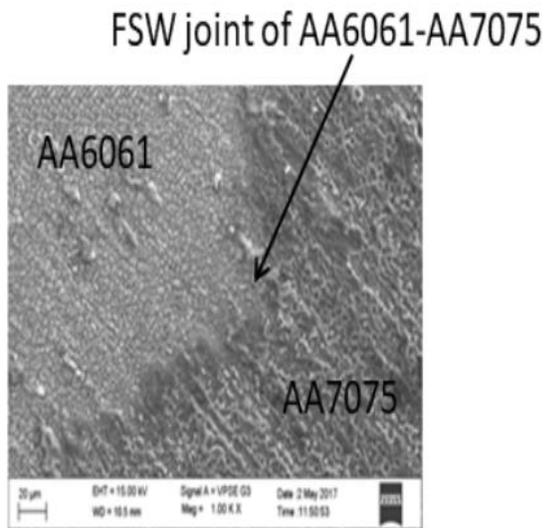


Table 2. Micro Hardness values of FSW AA6061-AA7075, 1000 rpm; 25 mm/min

SL. No	LOCATION	HARDNESS, HV	
		AA6061	AA7075
1	NUGGET ZONE	82	82
2	TMA ZONE	161	155
3	HA ZONE	82	156
4	BASE METAL	96	101

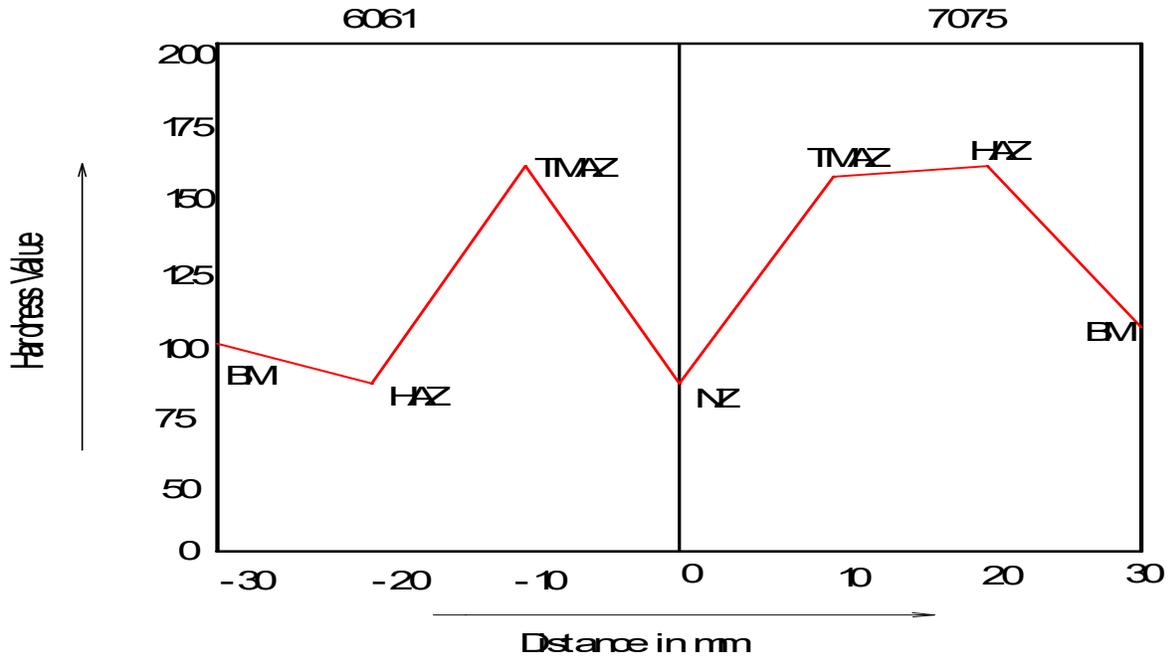
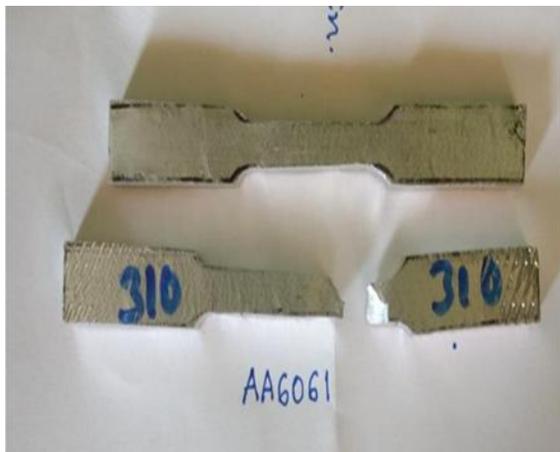


Fig.5. Micro hardness distribution of FSW AA6061- AA7075, 1000 rpm; 25 mm/min

Tensile testing of FSW samples

The samples for the tensile test were extracted from the FSW samples processed under various conditions 1000 rpm/25 mm/min, 1000 rpm/50 mm/min and 1500 rpm/25 mm/min, 1500 rpm/50 mm/min. In each processing condition three tensile samples were extracted according to the ASTM E8 standards as shown in the Fig. 6. and the test specimen was cut by

wire EDM process. The specimens that were prepared according to ASTM E8 were subjected to uniaxial tensile load and their characteristic curves obtained are shown in this section. The base material AA6061 and AA7075 are tested for tensile test is shown in the Fig. 6. and the values of tensile force, yield strength and percent elongation are shown in the table 3.



Base Metal : AA 6061



Base Metal : AA 7075

Fig. 6. Tensile samples of base metal AA6061 and AA7075 alloy

Table 3. Tensile strength of base metals

Sl. No.	BASE Metal	Tensile Strength (N/mm ²)	Yield stress (N/mm ²)	Percentage Elongation (%)
1	AA6061	339.19	294.67	11.64
2	AA7075	635.45	602.01	9.88

Table 4. Tensile strength of FSW welded specimens

SL. no	Welding parameters	Tensile strength (N/mm ²)	Yield stress (N/mm ²)	Percentage Elongation (%)
1	1000 rpm 25 mm/min	197.52	181.42	12.72
2	1000 rpm 50 mm/min	200.0	189.25	10.92
3	1500 rpm 25 mm/min	193.98	183.26	14.0
4	1500 rpm 50 mm/min	197.10	187.41	12.42

III. CONCLUSIONS

The present study aims primarily at the understanding of the mechanical behavior of dissimilar welded joints under different processing conditions and to examine the microstructure variations in nugget zone, thermo-mechanically affected zone/ heat affected zone (TMAZ/HAZ).

1) The macrostructure of the welded joints in the transverse cross section showed proper mixing of both the materials AA6061 and AA7075 in the nugget zone in all the processing conditions and resulted in the formation of good welds.

2) Grain refinement seems to be dependent on the heat input ratio, as the ratio of rotational speed to traverse speed increased the grain size increased. The lowest grain refinement 2 μm was observed at a tool rotational speed 1000 rpm and traverse speed 50 mm/min which is also the lowest heat input.

3) The hardness of the welded joint was found to be higher at the revolving speed 1000 rpm and traverse speed 50 mm/min. The grain refinement was to found to be lower in this processing condition.

4) Tensile strength increased with the decrease in heat input ratio, at tool rotational speed 1500 rpm and traverse speed 50 mm/min the maximum tensile

strength was observed. This exhibited the lowest heat input ratio among all the processing conditions.

5) Ductility was found to be maximum at the higher heat input ratio this can be attributed to defect free joints. The formation of defects in the low heat processing conditions is due to the formation of small voids due to insufficient heating during processing.

6) The current work proved that it is feasible to join dissimilar aluminum alloys of AA6061 and AA7075. The improvement in mechanical properties compared to the base material is very encouraging and such dissimilar welded joints are more helpful in special applications like aerospace etc.

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