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Friction Stir Welding Oof Dissimilar Aluminium Alloys (6061&7075) By Using Computerized Numerical Control Machine

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Abstract: Friction stir welding, a solid state joining technique, is widely being used for joining Al alloys for aerospace, marine automotive and many other applications of commercial importance. FSW trials were carried out using a computerized numerical control machine on (Al 6061 & 7075) alloy. The tool geometry was carefully chosen and fabricated to have a nearly flat welded interface (cylindrical & taper) pin profile. Important process parameters that control the quality of the weld are a) rotation speed (1600&1250rpm) b) traverse speed (120mm/min) and c) tool tilt angle 2^0 and these process parameters were optimized to obtain defect free welded joints. It is observed that, during the friction stir welding, extensive deformation is experienced at the nugget zone and the evolved microstructure strongly affects the mechanical properties of the joint. The present studies aimed to understand the micro structural changes and the associated mechanical properties during the FSW. The main aim of our project is to find the mechanical properties of friction stir welding of dissimilar aluminum alloys (6061&7075) by using CNC vertical milling machine. The limitations of FSW are reduced by intensive research and development. Its cost effectiveness and ability to weld dissimilar metals makes it a commonly used welding process in recent times.

Key words: Friction stir welding · Al (6061 & 7075) alloy · Microstructure · Tensile strength · Recrystalization

INTRODUCTION

Friction stir welding is a new welding technique for aluminium alloys invented by The Welding Institute, Cambridge, U.K., in 1991 [1]. This technique uses a non consumable steel welding tool to generate frictional heating at the point of welding and to induce gross plastic deformation of work piece material while the material is in a solid phase, resulting in complex mixing across the joint. A detailed account of the process has been provided byothers [1-3]. Although friction stir welding can be used to join a number of materials, the primary research and industrial interest has been to join aluminium alloys. Defect-free welds with good mechanical properties have been made in a wide variety of aluminium alloys, even those previously thought to be “unweldable” in thicknesses from less than 1 mm to more than 35 mm. In addition, friction stir welds can be accomplished in any position [4]. Clearly, friction stir welding is a valuable new technique for butt and lap joint welding aluminium alloys. Of importance to this work [5] and subsequent interpretation of results, is the FSW tool design and how it interacts with the work piece [6]. The steel tool is comprised of a shank, shoulder and pin, as shown in Fig. 1.

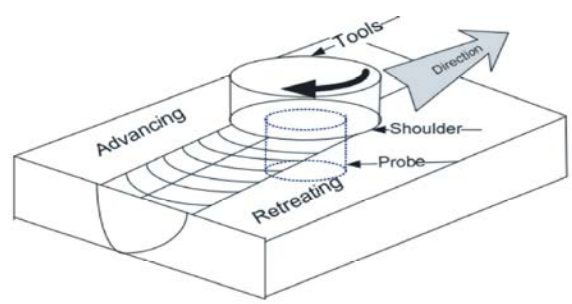

Fig. 1: Friction stirs welding

The welding tool is rotated along its longitudinal axis in a conventional milling machine and the work piece material is firmly held in place in a fixture. The shoulder is pressed against the surface of the metal generating frictional heat while containing the softened weld metal. The pin causes some additional heating and extensive

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Table 1: Chemical composition AA6061

Component	Al	Cr	Cu	Fe	Mg	Mn	Zn	Si
Wt.%	90.19	0.20	1.31	0.17	2.28	0.019	5.61	0.1

Table 2: Chemical composition AA7075

Component	Al	Cr	Cu	Fe	Mg	Mn	Zn	mm S w i el dia
Wt.%	97.67	0.064	0.19	0.25	0.80	0.12	0.11	mm 0. t7he

plastic flow in the work piece material on either side of the butt joint. As seen in the Fig. 1, the pin is cylindrical and tapered.

This tool was found to assist in ensuring that the plastically deformed work piece material is fully delivered around the pin, resulting in a void-free weld. To achieve full closure of the root, it is necessary for the pin to pass very close to the back plate, since only a limited amount of plastic deformation occurs below the pin and then only very close to the pin surface.

A Typical Butt Joint Welding Sequence Proceeds as Follows: The work piece material, with square mating edges, is fixture on a rigid back plate. The fixturing prevents the plates from spreading or lifting during welding and holds the material at a slight angle relative to the axis of the welding tool. The welding tool, fixed in its holder, is spun to the correct spindle speed and is slowly plunged into the work piece material until the shoulder of the welding tool forcibly contacts the upper surface of the material and the pin is a short distance from the back plate. At this point the welding tool is forcibly traversed along the butt joint, which continues until the end of the weld is reached. The welding tool is then retracted, generally while the spindle continues to turn. Once the tool is completely retracted, the spindle is stopped and the welded plate can be removed from the fixture. It should be noted that when the tool is retracted the pin of the welding tool leaves a hole in the work piece at the end of the weld.

Working Material Used (6061&7075): Alloy 6061 is one of the most widely used in the 6000 series. This standard structural alloy one of the most versatile of the heat treatable alloys is popular for medium to high strength requirements and has good toughness characteristics. It has an excellent corrosion resistance to sea water and also it's easily welded joined by various commercial methods. Since 6061 is heat treatable alloy, strength in its-T6 condition can be reduced in the weld region. Selection of an appropriate filler alloy will depend on the desired weld characteristics.

Table 1&2 shows the chemical compositions of plates of AA6061 & AA7075. To examine the weld ability of joints, 6061-T6 and 7075-T651 were joined to pure aluminium alloy by FSW.

High strength precipitation hardening 7XXX series aluminum alloys, such as 7075 are used extensively in aerospace industry. These alloys are difficult to join by conventional fusion welding techniques. Hence realizing a fusion-welded joint in such alloys without impairing the mechanical properties is a difficult task for the welding engineer. Consequently the welding engineer has to rely on rivets and fasteners with substantial increase in fabrication cost and structure weight [7].

The size of the shoulder of the tool and the diameter tool affects the grades of aluminium alloy AA6061 [1]. Studied the mechanical properties of AA2024 and AA 7075 aluminium alloys also we are referred [2]. These studies have reported the strength of these butt joints higher than the aluminium used in welding materials.

However, in the case of the aluminium alloys AA6061 and AA7075 also never had a reported and databases in research. For this reason, it is interesting. In the application of a friction stir welding in the different grades of aluminium alloys in this. For examine the microstructure and tensile strength of the weld to provide information on the application in the industry.

Experimental Procedure: The joining conditions are shown in a schematic diagram of FSW is shown in Fig. 2, in which the probe inserts, position was offset on the joint interface. The position in which the probe was inserted was offset on the grooved surface by 0.5 mm. The probe was inserted in the Al alloy (6061) side and the probe edge was slightly offset into the (7075) alloy. This joining method was suggested by some research. The dimensions of the materials (6061&7075) Al plates were 100 mm x 50 mm x 6. A high carbon high chromium tool is used for ding 6061 & 7075 Al alloy having the shoulder meter of 25 mm. The tool had a pin height of 5.7 and a 6 mm pin diameter.

Table 3: NC program for FSW of dissimilar joints2.1 Specimen of aluminium alloy

NO	COMMAND	DESCRIPTION
N0010	G90G94G17G71G40	Absolute positioning mode, metric unit
N0020	T02M06	Tool change number 02
N0030	S1600M03	Spindle speed on clock wise in rpm
N0040	G01X0Y0Z100F120	Linear interpolation feed rate 120mm/min
N0050	G01Z10F120	Linear interpolation feed rate 120mm/min
N0060	G01Z0F120	Linear interpolation feed rate 120mm/min
N0070	G01Z-3.5F100	Linear interpolation feed rate 100mm/min
N0080	G04F55	Dwell time is 55 sec
N0090	G01Z-5.75Y-55F120	Linear interpolation feed rate 120mm/min
N0100	G04F10	Dwell time is 10 sec
N0110	G01Z-4F80	Linear interpolation feed rate 80mm/min
N0120	G01Z10F120	Linear interpolation feed rate 120mm/min
N0130	G01Y0Z100F120	Linear interpolation feed rate 120mm/min
N0140	M05	Spindle turned off
N0150	M30	End of program

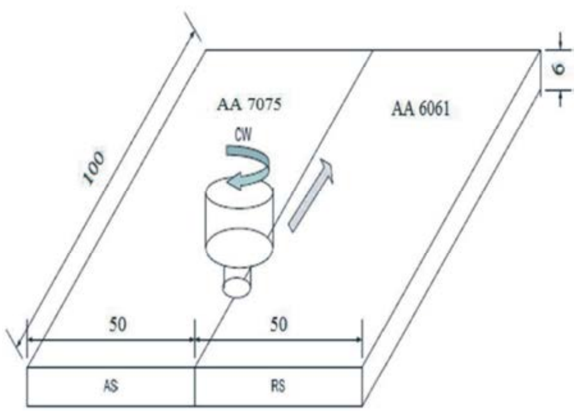


Fig. 2: The dimension of the specimen (unit in mm)

In here we are choosing welding parameter of the aluminium alloys (6061&7075). The Aluminium plates were welded using two different tool rotation speeds, two tool pin profile and one traverse speeds. The tool rotation speeds used in this study were 1250 and 1600 rpm and the tool traverse speeds of 120 mm/min were used. The tool tilt in all the trials was kept constant at 2°.

In this study, the (7075Al) alloy plate was positioned on the advancing side and the (6061Al) alloy plate was positioned on the retreating side. Square butt joints with 100mm _50mm _ 6.0mm rectangular plates were used and grooved surfaces were machined and degreased with acetone. Metallurgical investigations on a cross section of the joint were done after polishing and etching. Visual inspection of joints was carried out in order to find defects on the surface. Metallurgical investigations on a cross section of the joint were done after polishing and etching. The distribution of elements on the joint interface was examined using a scanning electron microscope (SEM). The mechanical properties of the joint were measured in tensile tests. The tensile tests were carried out at a cross-head speed of 120 mm/min. The shape of the tensile test specimens was rectangular and the width was 10mm.

Tensile test specimen

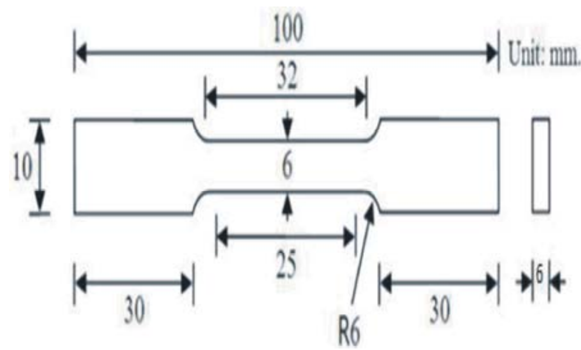


Fig. 3: Dimensions of the tensile specimen according to ASTME8M

RESULT AND DISCUSSIONS

Tensile Strength of Aluminium Alloys: The tensile strength was friction stir welded samples using tapered pin and cylindrical pin type tools at 1250rpm and 1600rpm is shown in Fig. 4 The results demonstrated that the tensile strength of samples processed via tapered pin produced more value than cylindrical pin type tool one. Further it can be explained that the tensile strength of tapered pin sample was around 30% and 15% higher than cylindrical one at 1250rpm and 1600rpm respectively. So it is suggested that taper pin as FSW tool can be selected for welding of Al 7075& 6061 dissimilar alloy [8].

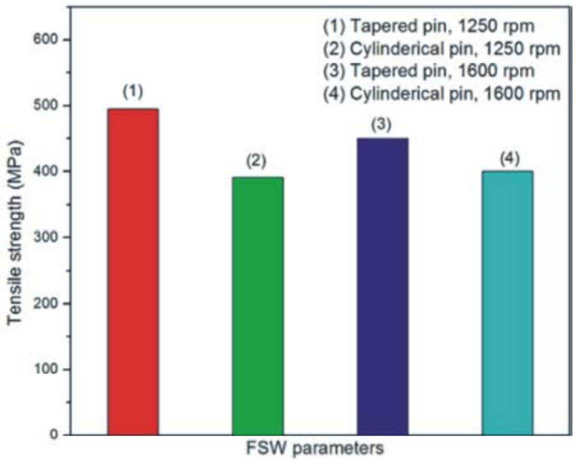


Fig. 4: The relationship between welding speed and tensile strength

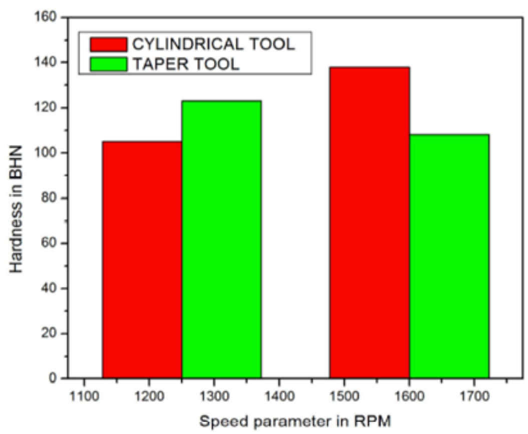
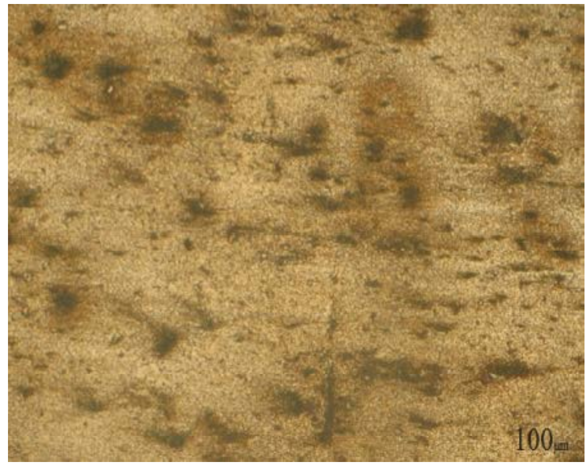


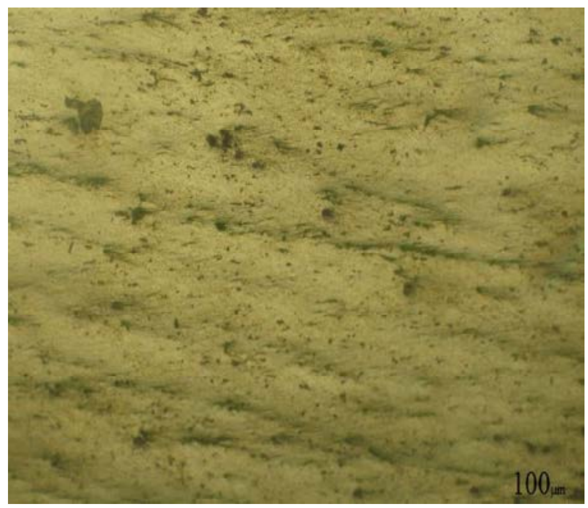
Fig. 5: Compare of cylindrical & taper tool

Hardness of Aluminium Alloys: For the hardness test results showed that the highest measured hardness is 131 BHN at weld centre was welding speed 120 mm/min in cylindrical toolspeed was 1600 rpm to be observed from Fig. 5. The left hand side of the cylindrical tool graph are shown in fig. Will notice that the left hand side of the taper tool value hardness is 123BHN at weld centre was welding speed at 120mm/min in 1250rpm. AA 6061 a value that is higher than the centre is expected of hem as a tool to bring material AA 7075 was merged with the AA 6061, making the show hardness is high ver the centre line. For the lowest hardness was 105 HN at the speed of 120 mm per minute in 1250rpm n cylindrical tool. The observer will notice that the alues are close to the base material of aluminium lloy 6061 is expected tools carry material of luminium alloy 6061 get to this area have volume ather than taking base material aluminium alloy 7075 was included in the centre of the weld that made lower ardness.

MICROSTRUCTURE OF ALUMINIUM ALLOYS



(a) AA6061



(b) AA7075

(c) Centre of welded zone

Fig. 6: The microstructure of welding speed to 120 mm/min

Fig. 6shows the microstructure of the work piece, the speed to 1250 rpm and welding speed to 120 mm/min and taper tool. Fig. 6 (a) shows the structure of aluminum alloy

6061 of the show noted that the structure grain growth. The structure of this grain growth affects the tensile strength. The erosion of work try to collapse the core material for Fig. 6 (b) shows the microstructure of the weld will notice that some areas of the white on black. A little white space, is expected to be part of the aluminum alloy 6061, which is not included in nugget the aluminum alloy 7075 in the area of welding have effect on the hardness. When testing the hardness of this value was close to where materials are aluminium alloy 6061 Fig.6(c) shows the microstructure of the group of aluminum alloy 7075, which noted that the grain fine than The microstructure of aluminum alloy 6061 is 100ìm which fine structure is expected to affect the tensile strength and hardness testing then make the test value higher [9].

CONCLUSION

The experimental application of a friction stir welding of the butt joints between aluminum AA6061 and AA7075 by changing the parameters of speed and tool pin profile then study mechanical behaviour of the friction stir welding done on the material and to do the test for tensile strength and microstructure of aluminium 6061 and 7075. The results can be summarized as follows. [1]. Conditions, the best speed are 1250 rpm and a welding speed of 120 mm/min. A stirring 2 degree tilt the weld is complete and tensile strength 485Mpa. [2]. The maximum hardness of 131 BHN is welding speed of 120 mm / min in cylindrical tool at 1600rpm, joints by submerged friction stir welding' Materials and Design 32: 4825–4831. and also the hardness of 123 BHN is welding speed of 120 mm/min in taper tool at 1250rpm, which resulted in a high tensile strength [3]. The weld zone was divided into three regions (centre of weld AA6061, AA7075). The taper tool speed of 1250rpm shows the microstructure of the centre of welded zone (100µm) had fine grain due to dynamic recrystallization had affect to the tensile strength and hardness testing higher.

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