TENSILE STRENGTH AND HARDNESS TEST ON FRICTION STIR WELDED ALUMINIUM 6061-T6 AND 5083-H111-O ALLOYS

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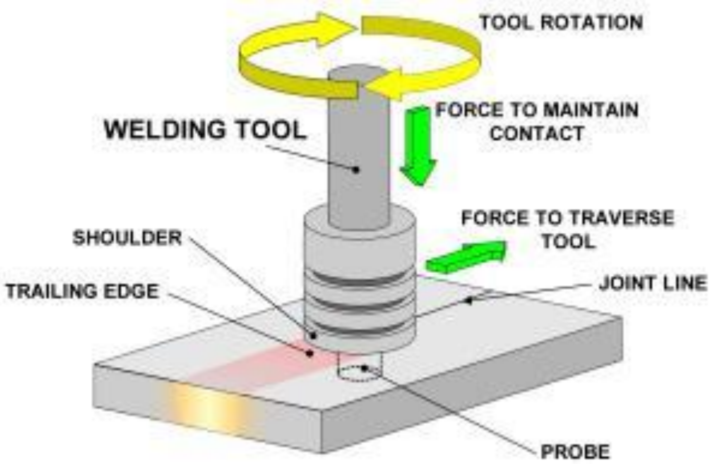
ABSTRACT: As friction stir welding is widely used in automobile and aerospace sectors for the smooth finishing and strength of the materials, there is still scope to take up further research in this area. In this reasearch paper, it is discussed the hardnesss and tensile stength of two dissimilar materials after the friction stir welding is performed on two different aluminium plates adjacent to each other. After completing the welding process, it is concluded that the development of cracks were identified, tensile strngth of the material increased after welding is performed as well as the results obtained by the application of different types of tool are also examined.

Key words: Friction stir welding, dissimilar metals,cylindrical tool, hardness, tensile strength

I. INTRODUCTION:

Friction Stir Welding is one of the new entrants to the solid state joining technique which have made a remarkable progress in welding technology. Wayne Thomas invented friction stir welding at TWI in 1991 has become field of interest of many researchers due to high demand in joining process in the ship buiding, railway and aerospace industries especially in the field of aluminum alloy fabrication. FSW is an eco-friendly process that conducted various butt and lap welding for ferrous and non-ferrous metals and plastics[1]. Friction Stir Welding (FSW) is a process in which a rotating cylindrical tool with a profiled pin and a shoulder is plunged into the abutting plates to be joined and traversed along the line of the joint. A schematic of the friction stir welding process is shown in Fig. 1.The plates are clamped tightly on to the bed of the vertical milling machine equipment to prevent them from coming apart while the welding process takes place. A cylindrical tool rotating at high speed is slowly plunged between the two plates, until the shoulder of the tool touches the top surface of the plates. To maintain the contact between the tool and the material, a downward force is applied. During the process, frictional heat is generated between the tool and the material which causes the plasticized material without reaching the melting point, to get heated and softened. The tool is then traversed along the joint line, until it reaches the end of the weld. In order to achieve complete through-thickness welding, it should be noted that, the length of the pin should be slightly less than the plate thickness, since only limited amount of deformation occurs below the pin. The tool is withdrawn upon reaching the end of the weld, while it is still being rotated. As the pin is withdrawn, it leaves a keyhole at the end of the weld[2].



Fig(1) Schematic representation of Friction Stir Welding.

II.MATERIALS AND METHODS:

A. **MATERIALS**: In this work the materials that have been used are two dissimilar aluminum alloys that are AA 6061-T6 and AA 5083-H111-O[3]. When compared to other material aluminum is softer metal and very light weight, mostly used in all industries.

The density of Al 6061 is 2.7g/cm3 and ultimate tensile strength is 275-350 Mpa. AA 5083 is 2.65g/cm3, Ultimate tensile strength is 300Mpa. In this welding process, high speed steel is used as a tool material and the thermal conductivity of steel is 19 w/mk. specific heat is 0.640 j/g c.

B. **METHODS:** When the dissimilar aluminum alloys are welding with other fusion welding processes the material properties mostly may differ. Because the electrode which is using, is the opposite material to the plate. It was proved that these materials could be efficiently welded by using the Friction Stir Welding process. And mostly the material properties will not change .FSW has various advantages over other welding processes like no hot cracking of the welded very less residual stresses, safe and environment friendly apart from others.

After the materials were welded, various tests like Tensile strength test, Brinell's hardness test and the microstructure tests were conducted at the welded joint.

III.EXPERIMENTAL WORK:

The Experiments have been conducted on Vertical Milling machine The Milling machine provides an alternative way to produce friction stir welds when the actual FSW machine is not available.

A. Work piece:

The materials used in this work are AA 6061-T6 and AA 5083-H111-O the plates have been cut into the required size by shear cutting. Single pass welding procedure is used to fabricate the joints.

Work piece specifications:

Length:100mm ; Breath: 50mm ;Thickness: 5 mm
The chemical composition and mechanical properties of base metals are given in Tables (A) and (B).

Table (A): AA 6061-T6

ELEMENT	% PRESENT
Magnesium(Mg)	0.80-1.20
Silicon(Si)	0.40-0.80
Iron(Fe)	0.0-0.70
Copper(Cu)	0.15-0.40
Titanium(Ti)	0.0-0.15
Zinc(Zn)	0.0-0.25
Manganese(Mn)	0.0-0.15
Others (Total)	0.0-0.15
Others(Each)	0.0-0.05
Aluminium (Al)	Balance

Aluminum alloy 6061(used for both aerospace and marine alloys) is a medium to high strength heat-treatable alloy with strength higher than 6005A. Although reduced strength in the weld zone and medium fatigue strength, it has very good weld ability and very good corrosion resistance. It has good cold formability in the temper T4, but limited formability in T6 temper and it is not recommended for very complex cross sections. Applications Alloy 6061 is typically used for heavy duty structures like truck frames, ship building, rail coaches including helicopter rotor skins.

Table (B): AA 5083-H111-O

ELEMENT	% PRESENT
Magnesium(Mg)	4.00-4.90
Manganese(Mn)	0.40-4.90
Iron(Fe)	0.40 Typical
Silicon(Si)	0.0- 0.40
Titanium(Ti)	0.05-0.25
Chromium (Cr)	0.05-0.25
Copper (Cu)	0.10 Typical
Others (Total)	0.0-0.15
Zinc (Zn)	0.0-0.10
Aluminum (Al)	Balance

Aluminum AA5083 (used for marine alloys) is known for exceptional performance in extreme environments. 5083 is highly resistant to attack by both seawater and industri-al chemical environments. Alloy 5083 also retains excep-tional strength after welding. It has the highest strength of the non-heat treatable alloys. Applications Alloy 5083 is typically used in ship building and rail cars.

Tool Specifications and profile:

The design of the tool is a critical factor as a good tool can improve both the quality of the weld and finishing of the material surface. In this study both Round and Square pin tools are used which are non consumable.

Tool specifications:

High speed steel.

Fig (2): Round tool and square tool

Tool Dimensions (For Square and round tool)

Shoulder Diameter: 25 mm

Shoulder length: 45 mm

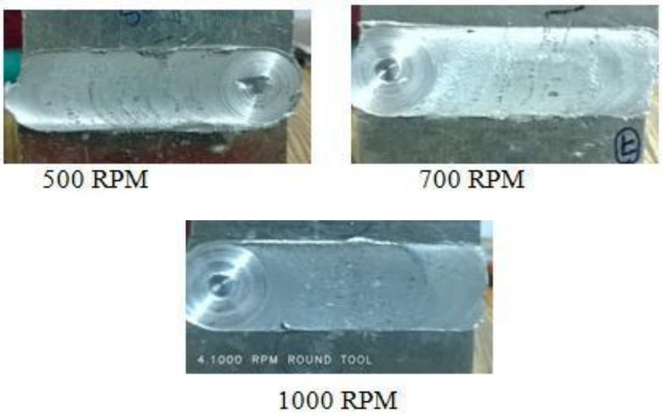
Pin Diameter: 6x6 mm (for square tool)

5 mm (for round tool)

Pin Length: 4.5 mm

B. **Weld Trails:**

Main difficulty encountered in a FSW is the process optimization. Different parameters like tool rotation (rpm), welding speed (mm/min) axial force (N), tool design etc. are involved in deciding the sufficient heat generation for the effective (quality) solid state joining of materials. Six sets of welding trails were made at the base material only by varying tool rotation speed and keeping down-ward force and welding speed constant



Fig(3): Welded with Round pin tool

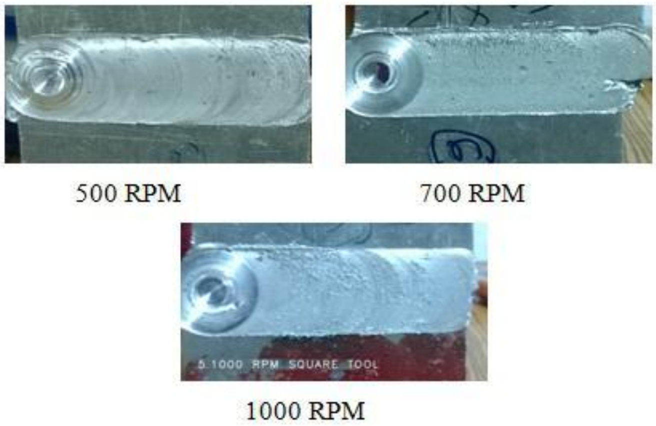


Fig (4): Welded with Square pin tool

Six Sets of welding trails made at work by varying tool rotation speed and welding speed kept constant.

S.No	Tool Rotation Speed(rpm)	Welding Speed (mm/min)	Tool Profile
1	1000	25	Round
2	1000	25	Square
3	700	25	Round
4	700	25	Square
5	500	25	Round
6	500	25	Square

Adequate Welding quality was obtained at rotational speed of 500 rpm, weld speed of 25 mm/min, and 1000 rpm at weld speed 25 mm/min and pressure 5 MPa as there are cracks occurred when observed with naked eye.

V.RESULTS AND DISCUSSIONS

A.Tensile Strength:

Tensile Specimens of required dimensions are prepared and has been carried out with help of universal testing machine(UTM).

Specimen Dimensions:100x50x5 (in mm)

Specimens after tensile test

Specimen Dimensions
Area for square tool: 180 N/mm2

Area for round tool: 98.17N/mm2

The Tensile Strength for specimen for a round tool is 133.79 N/mm2.The Tensile Strength for specimen square tool is 145.16 N/mm2

B. Rockwell Hardness Test:

Trail 1	108 HRB
Trail 2	177 HRB
Trail 3	109 HRB

The Rockwell scale is hardness scale based on the indentation hardness of material. The Rockwell test determines the hardness by measuring the depth of penetration of an indenter under a large load compared to the penetration made by preload. The Rockwell hardness tests were conducted to determine the hardness values of aluminum AA6061 alloy and AA5083 friction stir weldments at different rotational speeds and feeds of the different tool in a Rockwell Hardness Tester By using Rockwell 1/16 inch scale load value major 100 kgf and minor 10 Kgf hardness values as at 500 rpm square tool.

VI.CONCLUSION:

In this investigation an attempt has been made to study the effect of tool pin profiles and welding parameters on the formation of friction stir weld and tensile properties in AA5083 and AA6061 aluminium alloy. From this investigation, the following:

1.Friction stir welding is performed to join 5mm thick plates of Aluminium alloys with varied parameters like tool rotation speed (rpm), welding speed (mm/min) and downward pressure (MPa).

2.Quality welds are produced with the tool rotation speed of 500-1000 RPM at weld speed 25mm/min and down-load pressure 5MPa.
3.Joints fabricated at rotational speed of 500 rpm and weld speed of 25 mm/min at Square tool profile exhibited superior tensile strength properties.

4.At high rotational speed cracks were observed by visual inspection.

5.In FSW it is understood that increasing the welding speeds, decreasing the tool rotation speed and reduction in thickness which in turn increases the tensile properties.

From the results, the square tool is better than cylindrical tool for aluminum alloy.

REFERENCES:

[1] Thomas W H, Threadgill PL and Nicholas ED *Science and technology of welding and joining, Vol* 4 page 365, 1999
[2] B. Prashanth, T.N. Ravikanth, "An Experimental Study On Friction Stir Welded 7075 Aluminum Alloy- Corrosion Properties And Micro Structure", International Journal of Innovative Research in Science, Engineering and Technology, Volume-5, PP 10004-10009, ISSN:2319-8753, 2016
[3] Sydney H Avner, Introduction to Physical Metallurgy, Tata McGraw-Hill, 1997
[4] B.Prashanth, K.Shravan Kumar, "A Study on Friction Stir Processing of AA6061" , International Journal & Magazine of Engineering, Technology, Management and Research, Volume-2, PP 1373-1380, ISSN:2348-4845, 2015
[5] Pao P S, Gill S J, Feng C R and Sankaran K K *Scripta Materialia*, *Vol.* 45, Page 605, 20015
[6] L.Karthikeyan, V.S.Senthilkumar, V.Balasubramaniam, S.Natarajan, Mechanical property and microstructural changes during FSP of cast Al2285, Materials and Design 30 (2008) 2237 – 2242 [2]
[7] K.Surekha, B.S. Murthy, K. Prasad Rao, Effect of processing parameters on the corrosion behaviour of friction stir processed AA2219 aluminium alloy, Solid State Sciences 11 (2009) 907 – 917
[8] R.S. Mishra, Z.Y. Ma, Friction stir welding and processing, Materials Science and Engineering R 50 (2005) 1–78
[9] Dawes C J and Thomas W M, *Welding Journal*, Vol.**75 Page** 41, 1996
[10] C.I. Chang, X.H Du, J.C. Huang, Achieving ultrafine grain size Mg-Al-Zn alloy by FSP, Sriptamaterialia 57 (2007) 209 – 212
[11] S.R. Sharma, Z.Y. Ma, R.S. Mishra, Effects of FSP on fatigue behavior of A356 alloy, ScriptaMaterialia 53 (2004) 201 – 206
[12] ALuminium Handbook