OPTIMIZATION OF FRICTON STIR WELDING PARAMETERS FOR DISSIMILAR ALUMINIUM ALLOYS OF AL7075 AND 2014

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ABSTRACT: Friction stir welding (FSW), a solid-state joining technique, is being extensively used in similar as well as similar joining of Al, Cu,Ti,and their alloys. In the present study friction stir welding of two aluminium alloys AA7075 and AA2014 were carried out at various combinations of tool rotation speeds and feed and axial force.. In this experimental proper selection of input friction welding parameters necessary in order to control weld distortion and subsequently increase the productivity of the process. In order to obtain a good quality weld and control weld distortion, it is therefore, necessary to control the input welding parameters. **In this research work, experiments were carried out on AA 7075 and AA2014 of 6 mm thick using friction stir welding process with constant tool with various parameters** like that **RPM, Feed and Axial Load**. Experimentally analyzedcylindrical tool was used and compare to each other parameter and investigate which one parameter gives more higher tensile strength and other properties, and found the effect of FSW process parameters on mechanical properties of friction stir weld of aluminum alloys 7075 and 2014using constant profile. From the macro investigation the second test plate found good with the parameter 900 RPM 18 mm/min tool traverse and the axial force is 7 KN obtained the best parameter during the Friction welding processes.

1. INTRODUCTION:

Friction stir welding (FSW) is an innovative solid-state joining process invented in the 1990s by TheWelding Institute in the United Kingdom (UK). It is considered as one of the most significantwelding process inventions in the last two decades. Compared to other solid-state joining processes such as rotary friction welding and inertial welding, the FSW process is unique in that it enables theadvantages of solid-state joining for fabrication of continuous linear welds, the most common form ofweld joint configurations that are predominately made by the arc welding processes in today industry.

The specially designed tool has twoessential parts. The first part is the profiled pin extending along the rotating axis. The second part isthe shoulder. Rotating at high angular speeds, the pin plunges into the work piece until the shouldermakes full contact with work piece surfaces. The rotating tool then moves along the jointline with theshoulder fully in contact with the work piece surface under a relatively high axial forging force.Owning to largely the frictional heatingbetween the rotating tool and the work piece, the temperature in a column of work piece material under the tool is increased substantially, butremains belowthemelting point of the material. The increasein temperature softens the material, and allows therotating tool to mechanically stir the softened material flowing to the backside of the pin where it isconsolidated to form a metallurgical bond.

2.SCOPE AND OBJECTIVE:

2.1 SCOPE OF THE PROJECT

The focus of the research work will be concentrated in the mechanical performance and the stir zone microstructure by FSW lap and butt welded part having 100mm × 50mm × 6mm thick sheet Aluminum (AA7075) and 100mm × 50mm × 6mm thick sheet Al 2014using constant pin diameters. All the testing of welded part will be tested by ASTM standard. Cylindrical pin tool will used to conduct experiments.

In this research, Universal Testing Machine (UTM), Hardness testing machine IMAGE-J (Bead Geometry Analysis) will also be used to measure the. Friction stir processing is a method of changing the properties of a metal through intense, localized plastic deformation.

2.2 OBJECTIVES OF THE PROJECT:

For this research, the objectives that are tried to achieve by the researcher are:

1. To get optimum parameters for the materials under considerations i.e. Al- alloy of grade AL2014&AL7075.
2. To investigate the Various Mechanical behaviours
3. Defects occurring during the welding process

3. METHODOLOGY:

3.1 Friction stir welding:

Friction Stir Welding (FSW) is considered to be the most significant development in metal joining in a decade and is a “green” technology due to its energy efficiency, environment friendliness and versatility (Mishra and Ma, 2005). As compared to the conventional welding methods, FSW consumes considerably less energy. No cover gas or flux is used, thereby making the process environmentally friendly. The joining, does not involve any use of filler metal and therefore any aluminum alloy can be joined without concern for the compatibility of composition, which is an issue in fusion welding. When desirable, dissimilar aluminum alloys and composites can be joined with equal ease.

4. DIAGRAM:

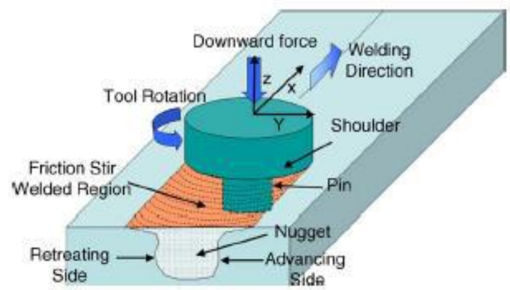


Fig .1 schematic diagram

5. WORKING PRINCIPLE:

Friction stir welding (FSW) produces welds byusing a rotating, non-consumable welding tool to locally soften a work piece, through heat produced by friction and plastic work, thereby allowing the tool to “stir” the joint surfaces. The dependence on friction and plastic work for the heat source precludes significant melting in the work piece, avoiding many of the difficulties arising from a change in state, such as changes in gas solubility and volumetric changes, which often plague fusion welding processes. Further, the reduced welding temperature makes possible dramatically lower distortion and residual stresses, enabling improved fatigue performance, new construction techniques, and making possible the welding of very thin and very thick materials. FSW has also been shown to eliminate or dramatically reduce the formation of hazardous fumes and reduces energy consumption during welding, reducing the environmental impact of the joining process. FSW can be used in any orientation without regard to the influence of gravitational effects on the process. These distinctions from conventional arc welding processes make FSW a valuable new manufacturing process with undeniable, economic, and environmental benefits.

According to Najafabadi et al. (2010), FSW is an innovative solid state bonding technique. In early years, it was introduced for light alloys. Recently, high performance tools materials are employed for FSW of high melting temperature materials such as titanium, nickel and steels.

6. MATERIALS DETAILS:

6.1ALUMINIUM-7075

7075 aluminium alloy is a very high strength aerospace aluminium and is commonly used in applications where the strength of the material is critical and where the need for good corrosion resistance is not important. Offering superior stress corrosion resistance, 7075 provides very high yield and tensile strengths which is dictated by the particular chosen temper.

6.1.1CHEMICAL COMPOSITION OF ALUMINIUM 7075

Table 6.1- Typical chemical composition for aluminum alloy 7075

ELEMENT	PERCENTAGE
Si	0.2 to 0.6
Fe	0.0 to 0.35
Cu	0.0 to 0.1
Mn	0.0 to 0.1
Mg	0.45 to 0.9
Zn	0.0 to 0.1
Ti	0.0 to 0.1
Cr	0.1

6.1.2 AL 7075 ALUMINIUM MECHANICAL PROPERTIES

Table: 6.2 Mechanical Properties

Density	2801 Kg/m^3
Melting Point	635^{0}C
Modulus of Elasticity	72Gpa
Thermal conductivity	134-160 W/m.K
Thermal expansion	23.5 x 10^{-6} /K

6.1.3 APPLICATIONS OF 7075 ALUMINIUM

Aluminum alloy 70751 is used in the same applications as 6061 aluminum. It is also used in roadtransport, Railtransport, Extreme sports equipment Source.

- Aircraft structures
- Gears & shafts
- Automotive

6.2 ALUMINIUM 2014

Aluminium 2014 is a very hardness and used to Automobile, and Aerospace applications .This is have a high ductility .It can be give the strength of frame with weightless. This material is one of the corrosion resistance.

6.2.1 CHEMICAL COMPOSITION OF AL 2014

Table:6.3Typical chemical composition for aluminum alloy 2014

ELEMENT	PERCENTAGE
Cr	0.1 % Max
Cu	3.9-5%
Fe	0.7% Max
Si	0.5-1.2%
Ti	0.15%Max

6.2.2 MECHANICAL PROPERTIES OF AL 2014

Table 6.4:Mechanical properties

Density	2.8g/cm^3
Young's modulus	73Gpa
Electric conductivity	34 IACS
Tensile strength	190 to 480 Mpa
Thermal conductivity	130 W/m-k

6.2.3 APPLICATION OF ALUMINIUM 2014

- Truck frame
- Aircraft structure
- Automobile frame

7. TOOL DETAILS:

Aluminum alloy was used as base metal to perform friction stir welding in this study. The prepared samples were welded using straight cylindrical threaded tools with shoulder diameters 18mm.

Fig .2 .TOOL DESIGN

8.PARAMETERS DESIGN:

Table 8.1Input parameter details

T.NO	SPEED RPM	TOOL-TR mm/min	AXFC KN
1	800	17	6
2	900	18	7
3	1000	19	8
4	1100	20	9
5	1200	21	10

9.TESTING METHODS:

9.1INTRODUCTION OF HARDNESS

There are three types of tests used with accuracy by the metals industry; they are the Brinell hardness test, the Rockwell hardness test, and the Vickers hardness test. Since the definitions of metallurgic ultimate strength and hardness are rather similar, it can generally be assumed that a strong metal is also a hard metal. The way the three of these hardness tests measure a metal's hardness is to determine the metal's resistance to the penetration of a non-deformable ball or cone. The tests determine the depth which such a ball or cone will sink into the metal, under a given load, within a specific period of time. The followings are the most common hardness test methods used in today`s technology:

9.2 ROCKWELL HARDNESS TEST

1. Rockwell Hardness systems use a direct readout machine determining the hardness number based upon the depth of penetration of either a diamond point or a steel ball. Deep penetration indicated a material having a low Rockwell Hardness number.

2. However, a low penetration indicates a material having a high Rockwell Hardness number. The Rockwell Hardness number is based upon the difference in the depth to which a penetrator is driven by a definite light or “minor” load and a definite heavy or “Major” load.

3. The ball penetrators are chucks that are made to hold 1/16” or 1/8” diameter hardened steel balls. Also available are ¼” and ½” ball penetrators for the testing of softer materials.

4. There are two types of anvils that are used on the Rockwell hardness testers. The flat faceplate models are used for flat specimens. The “V” type anvils hold round specimens firmly.

5. Test blocks o0r calibration blocks are flat steel or brass blocks, which have been tested and marked with the scale and Rockwell number. They should be used to check the accuracy and calibration of the tester frequently.

Using the “B” Scale;

a. Use a 1/16 indenter

b. Major load: 100 Kg, Minor load: 10 Kg

c. Use for Case hardened steel titanium, tool steel.

9.2.1HARDNESS VALUE-HRB VALUE

Table: 9.1 hardness value –HRB value

SAMPLE	S1	S2	S3	S4	S5
AL7075 &AL2014	37	31	39	30	34

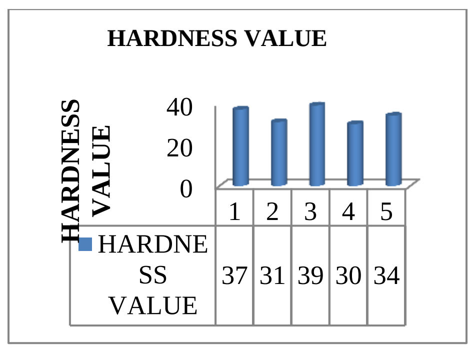


Fig.3.HARDNESS TEST

9.3 IMPACT TEST

In our Project Impact Strength determined through impact testing machine bycharpymethod. Specification of the machine and Size of the specimen

Energy Range = 0 – 300 J

Least Count (1 Division) = 1J

Specimen size =10 X 10 X 55 mm

Notch =V NOTCH

Notch Depth =1mm

9.3.1 IMPACT TEST RESULT

Table:9.2 Impact test value

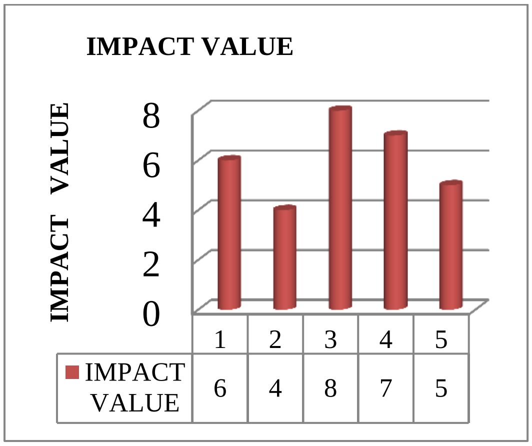
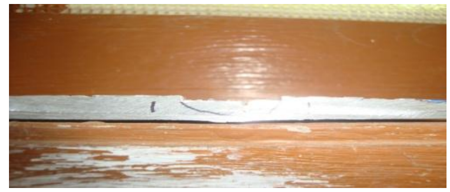


Fig .4.IMAPCT TEST

9.4 DEPTH PENETRANT TEST

Inadequate weld bead dimensions such as shallow depth of penetration may contribute to failure of a welded structure since penetration determines the stress carrying capacity of a welded joint .To avoid such occurrences the input or welding process variables which influence the weld bead penetration must therefore be properly selected and optimized to obtain an acceptable weld bead penetration and hence a high quality joint. To predict the effect of welding process variables on weld bead geometry and hence quality researchers have employed different techniques.

VIEW OF TEST PLATE -1



T.NO	SPEED RPM	TOOL-TR Mm/min	AXFC KN	IMPACT
1	800	17	6	6
2	900	18	7	4
3	1000	19	8	8
4	1100	20	9	7
5	1200	21	10	5

SPEED-800, TOOL-17, AXFC-6

Fig.5 Test plate 1

VIEW OF TEST PLATE -2

SPEED-900, TOOL-18, AXFC-7

Fig .6 Test plate 2

VIEW OF TEST PLATE -3

SPEED-1000, TOOL-19, AXFC-8.

Fig.7Test plate 3

VIEW OF TEST PLATE -4

SPEED-1100, TOOL-20, AXFC-9

Fig.7.Test plate 4

VIEW OF TEST PLATE -5

SPEED-1200, TOOL-21, AXFC-10

Fig .8.Test plate

9.4.1 VARIOUS SIZES OF BED WIDTH, DEPTH OF PENETRATION OF-AL7075FSW

Table: 9.3Depth of Penetration

SAMPLES	AREA	MAX	ANGLE	LENGTH
S1	0.241	234	0	10.483
S2	0.287	253	90	11.63
S3	0.183	255	0	2.836
S4	0.388	255	90	13.391
S5	0.440	254.5	0	16.33

10. CONCLUSION AND RESULT

Welds were obtained according to the experimental design with using without filler materials. All welds were defect free. The intermixing of metals was also found in the welded samples. During the FSW process, the materials were transported from the advancing side to retreating side behind the pin where the weld was formed. Finally concluded the second test plate with the parameter 900 RPM 18 mm/min tool traverse and the axial force is 7 KN obtained the best parameter during the Friction welding processes.

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